THE CODES
OF GOOD AGRICULTURAL PRACTICE
FOR THE LENINGRAD REGION

RULES AND RECOMMENDATIONS

PART 1
Animal Husbandry
and Fodder Production

St. Petersburg 2006

TABLE OF CONTENTS

INTRODUCTION

Agriculture, and animal husbandry in particular, is an essential pollution source for the Baltic Sea. The countries located in the Baltic Sea catchment area have established an efficient long-term cooperation aimed at reducing the nutrient loads to the watercourses. With this aim in view, national Codes of Good Agricultural Practice (GAP) have been developed and put into practice in the EU member countries to meet the requirements set by the EU Nitrates Directive and other environmental regulations of the European Commission.

The Codes of GAP are a system of recommendations, rules and principles. They cover a wide range of agricultural activities, which aim at reducing the nutrient loads, improving animal welfare, preserving the rural landscape and maintaining the biological diversity of plants and animals as well as improving the working safety of farmers.

The current legislation in Russia is relatively complicated - it provides very detailed regulations for the protection of the environment - so the major part of the farmers fails to know all of them and to apply them in their daily routine. The Codes of GAP were formulated to meet the needs of farmers in this respect, being in full compliance with the Russian environmental legislation, the Leningrad Region's laws and Recommendations of the Helsinki Commission (HELCOM).

The *Codes of Good Agricultural Practice* project was implemented in a trilateral co-operation between Russia, Finland and Estonia.

The Codes of GAP for Leningrad Oblast were designed and written by a Russian - Finnish expert team. The Ministry of the Environment, Finland, financed the preparation of the *Codes of GAP* for Leningrad Oblast. The Ministry of Agriculture from Estonia participated in the writing process by commenting the CGAP from Estonia's relevant perspective. Estonia had recently prepared its own CGAP when joining the EU. The project operated in close co-operation with the SIDA funded project *Agriculture and Environment in Leningrad Oblast* (AELO) and received valuable

support from the AELO in the form of technical expertise and provision of seminar arrangements.

The first part of the *Codes of GAP* deals with environmental aspects of dairy and cattle farming, feed production and pastures, since dairy farming is the key branch of Leningrad Oblast agriculture. At present this region witnesses a growth trend in dairy and cattle farming and more intensive investment in this branch. One of the results is a bigger amount of manure, which is accumulating on dairy and cattle farms, and excessive spreading of fertilizers and plant protection chemicals in intensive fodder production. This can create a serious threat for the close-by ecosystems, ground and underground waters. Following these rules and recommendations not only protects the adjacent ecosystems but also contributes to the farm resources economy, more efficient use of land and premises, and generates an aesthetically pleasant and attractive image of the farm surroundings for consumers and investors.

Introduction of the *Codes of GAP* into practice will reduce the negative impact of farming and animal husbandry on the environment and also improve the quality and competitiveness of agricultural production. Moreover, the elaboration and use of the Codes of GAP will promote the good relations between the Russian Federation and the EU member states.

The *Codes of GAP* are designed in the first place for agricultural producers: farmers, experts and managers of agricultural companies, and the persons who have permanent business contacts with them. They will also be of use for the specialists and officers from regional Agriculture Committees, experts of agricultural extension and advisory services as well as in educational and training agricultural institutions.

Finnish Gulf water in the protected place of Leningrad Oblast.

1. SOURCES OF NEGATIVE AGRICULTURAL IMPACT ON THE ENVIRONMENT

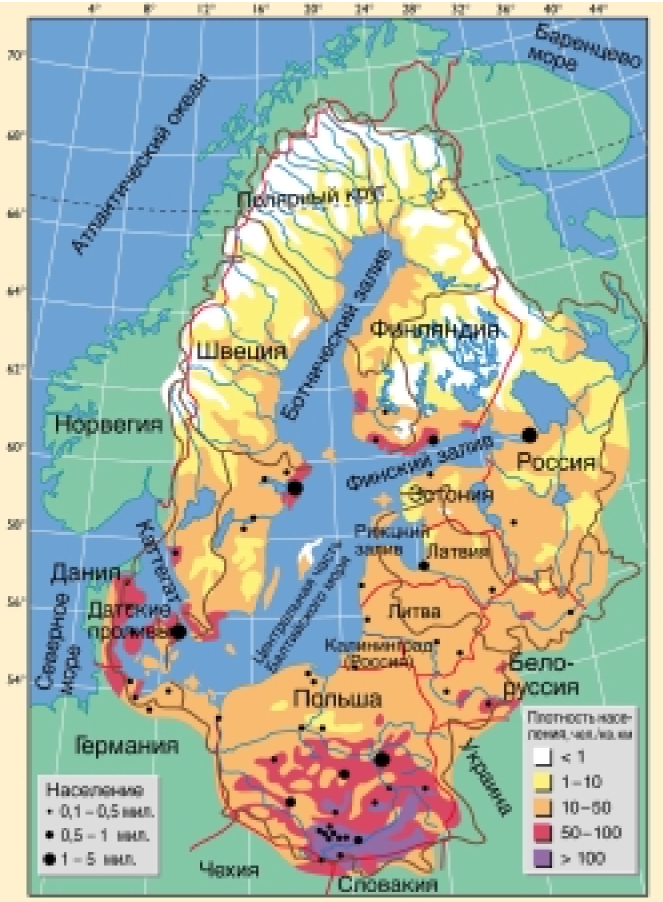
«Agricultural objects management should include strict observance of environmental requirements, and implementation of the measures to protect the land, soils, water bodies, plants, animals and other organisms against the adverse effect of economic and other activity on the environment»
Federal Environmental Protection Law of the RF, Article 42.

In the Federal Environmental Protection Law the following definitions are used:

- Environment is the complex of components of natural environment, natural-and-anthropogenous, and antropogenous objects.

- Natural Environment (Nature) - is the complex of components of natural environment, natural and natural-anthropogenous objects.

- Components of Natural Environment are land, earth interior, soils, surface and ground water, atmospheric air, plants, animals and other organisms, as well as the ozone layer and near-earth space, which together provide the favourable conditions for life existence on the Earth.



Agriculture is based on the use of natural resources, which have to be properly managed. Environmental protection should be based on the exclusion of the methods and technologies, which could cause the negative changes in the landscape.

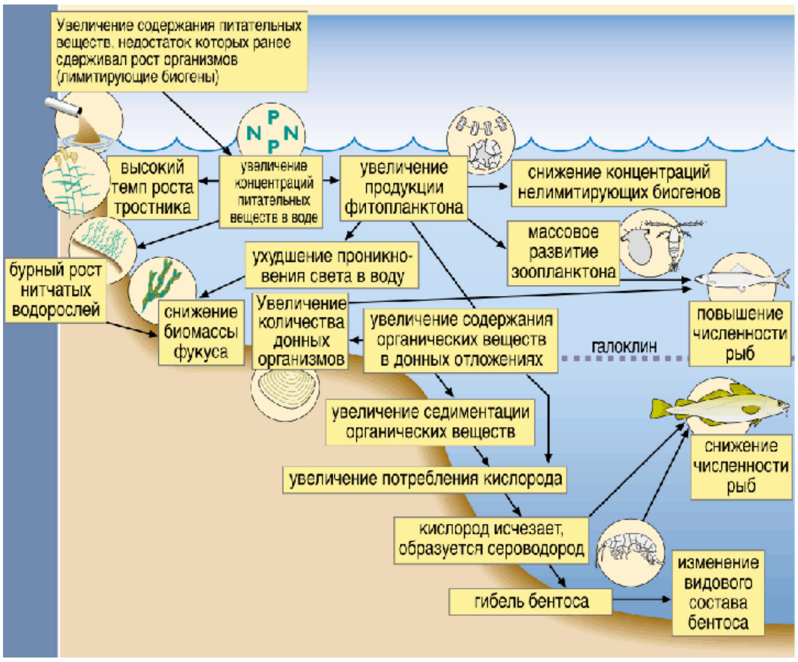
Any farm – be it a big joint-stock company, family farm or personal gardening plot - occupies a certain piece of land with specific soil pattern and vegetation. In its turn, this area is located within a certain agro-landscape, which features, among others, water flows generation, direction and rate, and the structure and dynamics of surface and ground water.

All landscape units of Leningrad Region belong to the geosystem of the Baltic Sea, and all surface water flows enter the Baltic Sea. In general the Baltic Sea receives around 80 cubic kilometres of water from the surface sources. Annual atmospheric precipitation in Leningrad Oblast is 700 mm, and approximately half of it is absorbed by plants,

and a substantial part evaporates. However more than 30% of the precipitation percolates through the soil or runs off the surface to add to the ground water. In other words, 2500 tons of water pass through each hectare of land annually. For many centuries since the glacier left, all easily-soluble substances were being washed out from the soil. Natural ground vegetation and soils of the area represented closed ecosystems – biotic communities, which retained in the biomass and humus only the amount of biophil elements needed for their existence. Nearly no elements left the ecosystem limits. This resulted in poor mineralization and low nutrients content in surface and ground waters in this region.

Human activity introduces additional amounts of nitrogen, phosphorus and other elements to the environment with industrial, agricultural and municipal waste. The content of nitrogen and phosphorus in natural waters is growing. In their turn, these elements serve as nutrients for some algae; resulting in ***eutrophication*** of aquatic systems.

Eutrophication is the rise of primary biological production in aquatic systems due to increased concentration of biogenic substances, primarily nitrogen and phosphorus. The intensive growth of biota and under-mineralization leads to accumulation of organic substances in water bodies. The increase of content of nutrients in the water to a certain level creates the favorable feeding conditions for fish and promotes their population. But then the water quality may gradually become worse, algal bloom (enhanced growth of blue-green algae) starts, river and lake banks are overgrown with vegetation, and poor water transparency and low dissolved oxygen content are observed. Large-scale eutrophication causes fish deaths and adverse effects on other hydrocoles.



Practically all agricultural objects and technologies have a chemical, biological, physical and mechanical effect on the basic components of the environment, thus contributing to landscape degradation.

Agricultural landscape degradation is soil acidification, over-compaction, bog formation, erosion (outwash), soil deflation (wind erosion), depletion of organic substances and nutrients available for plants, soil pollution with hazardous substances.

Agricultural objects include agricultural lands, technologies, machines and equipment for agriproducts production and processing, vehicles, storehouses, storages, power facilities, machinery repair and storing sites, etc.

The potential key sources of environmental pollution and degradation of agricultural landscapes are as follows:

Animal husbandry

1. Current technologies of animal housing and machines and equipment for waste removal allow considerable dilution of animal excrements with water that drastically increases their humidity and the risk of liquid manure access into the water bodies.
2. Lack of properly equipped manure storages or low capacity of existing manure storages. On most farms the amount of manure accumulated during the stall period is twice as large as the manure storing capacities. This results in the washing out of manure by rainwater, overfilling of manure storages, and the leakage of the liquid fraction.
3. Current year-round disposal of liquid manure on the fields, the use of terrain folds and earthen field sites for manure storing, and the lack of protective facilities to catch and accumulate the manure-contaminated waste and storm water on the farm territory are of particular hazard to the environment.
4. Excessive utilization of pasture areas causes soil over-compaction and increase of field surface roughness.

Feed production

1. Misuse of mineral fertilizers may result in surplus content of nitrogen and potassium in agri-products, an upset of the nutrients balance, and excessive introduction of nitrogen and phosphorus into environment. The latter will cause eutrophication.
2. The fertilizers, when applied to soil, introduce both nutrients and ballast substrates, which may contain heavy metals and toxic compounds. The impact

of heavy metals on agricultural ecosystems is manifested not only in contamination of agricultural products that limits their use, but also in direct toxic effects on soil, plants and animals. Liberal application of organic and mineral fertilizers, which contain heavy metals, results in gradual accumulation of the latter in soil, and their concentration may reach a hazardous level.

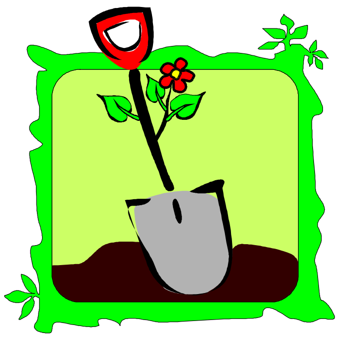
3. Plant protection chemicals also have an adverse effect on environment as a whole, since practically all pesticides are toxic for animals and people.
4. Non-compliance with storage precautions of fertilizers and plant protection chemicals. Improper storing of mineral fertilizers and pesticides, i.e. in the open or in the under-equipped warehouses, results in environmental pollution.
5. Plowing of smooth hill slopes encourages the development of erosion.

Use of agricultural machinery

1. Environment pollution with fuels and lubricants during repeated annual cultivation of arable lands via breaks of sleeves and pipelines of tractors, combine harvesters and agricultural machines, and also with the leaks during refueling. Storage of fuels and lubricants in under-equipped warehouses poses an environmental threat as well.
2. Soil over-compaction due to the impact of agricultural wheel and track machines on soil, which has not reached the physical maturity in spring or is saturated with moisture during incessant rains in summer and autumn. Over-compaction of the arable layer, and often also the subsurface horizon, reduces water permeability of soils and contributes to soil structure disturbance.

Farm managers and owners must assess the farm performance in terms of environmental protection and with due account for the above listed pollution sources, and to develop an action plan to correct the revealed violations.

2. PRINCIPLES OF ENVIRONMENTALLY FRIENDLY FARMING



There are two basic principles of making the arable farming environmentally friendly. One is the old law applied to prove a theorem: if and only if. Only needed things are to be done. The second principle concerns the overall environmental function of agricultural lands: the field must be always under green cover (covered with crops).

2.1. Soil and Climatic Resources of Leningrad Oblast

2.1.1. Agricultural climatic resources

The sum of efficient temperatures (above 10º C) is 1400 – 1900. Annual frost-free period is 120 days. Annual precipitation is 700 mm, 280 mm fall during the vegetation period. Weather conditions are favorable for growing the crops, which feature short vegetation period and cold tolerance.

The non-grazing period of cattle housing exceeds nine months per year.

2.1.2. Soil resources

«Land proprietors, owners, and users, tenants included, are obliged to organize agricultural production in such a way that fertility restoration of the lands of agricultural designation is guaranteed … ».
Federal Law of the RF № 101, dated 16.07.1998, «On State Regulation of Fertility of Lands of Agricultural Designation»

The total area of Leningrad Oblast is 8390,8 thousand hectares. The agricultural lands occupy about 540 thousand hectares; that is less than 10% of the total area of Leningrad Oblast. They include nearly 352 thousand hectares of arable land. The bigger part of the arable land (85%) is under perennial grasses. Potatoes and other root crops occupy nearly 10 thousand hectares of the arable land.

A characteristic feature of agricultural lands is high diversity of relief and soils. Above 100 soil types are found here. The ranking order of local soils by their origin is shown in Table 1.

Table 1. Distribution of soils of different origin, %

Types of agricultural land	Sod-podzolic soils	Sod-podzolic clay soils	Swamp-podzolic and swampy soils	Rendzina	Alluvial soils
Arable land	52	23	10	13	2
Pasture	36.2	51.7	0.6	10.6	0.9
Hayfield	22.5	52.1	14.1	4.4	6.9

An important characteristic of soil is its texture, which defines the difference in moisture content, thermal and biological conditions of soil types, their intake capacity and tilling techniques.

Podzolic soils are subdivided into the following types according to physical clay content (fractions under 0,01 mm):

Sand	**Up to 10 %**
Sandy loams	**10 to 20 %**
Loams	**20 to 50 %**
Clay	**above 50 %**

Distribution of soils by their texture is presented in Table 2.

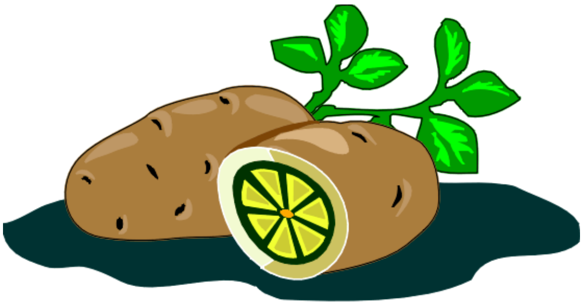
Table 2. Soil texture, % of investigated area

Agricultural land	**Surveyed area, ha**	**% of investigated area**			
		Sand, Silt	**Light-loam, loam**	**Heavy-loam, clay**	**Not determined**
Arable land	**347.3**	**24.2**	**63.7**	**4.4**	**7.7**
Pasture	**89.8**	**24.4**	**70.4**	**3.5**	**1.7**
Hayfield	**80.9**	**25.4**	**56.2**	**2.8**	**15.6**

Based on the agrochemical survey, 34 thousand hectares (20%) of hayfields and pastures have an acidic reaction and low phosphorus content, 84,3 thousand hectares (49%) have low potassium content.

Soil acidity and liming

High soil acidity is the key factor to limit most agricultural crops capacity.



The climate of Leningrad Oblast, with precipitation prevailing over evaporation, and short warm weather period (low temperatures) is responsible for excess soil acidity in this region. Soil formation takes place in humid environment. The water contains carbon dioxide, which actively dissolves the limestone and many other minerals. Calcium and other nutrients travel with the moisture through the soil layers and are lost with the ground waters. Annual loss of $CaCO_3$ due to leaching is 200 to 300 kg/ha on acidic soils, and up to 600 kg/ha on carbonated ones. Decalcification increases up to 400 to 700 kg/ha, when mineral fertilizers are applied on limed soils.

Besides natural factors, human activity also causes excess soil acidity:

- calcium and magnesium export with the crop yield;
- acid rains;

- application of acid-forming mineral fertilizers.

Acidic soils exhibit a set of unfavorable properties and have an integrated effect on plants and micro flora. Root growth and plant development suffer when the soil becomes too acid. Elevated acidity has a negative impact on physical and chemical state of the plasma of root cells and on their permeability that results in poor uptake of nutrients from the soil and fertilizers. Plants are most sensitive to soil acidity at the early development stage, when acidic reaction causes strong disturbances in their carbohydrate and protein metabolism and has an adverse effect on generative organs. This results in a dramatic drop of crop capacity.

An important factor of harmful effect of acidic soils is the low content of calcium and magnesium. The uptake of these elements by plants from acidic soils is extremely difficult due to the antagonism with the cations of hydrogen, aluminum, manganese and iron. As a result, many crops (leguminous, cabbage, onion, garlic) suffer from the deficit of calcium and magnesium as nutrients in acidic soils.

Most agricultural crops grow best on slightly acid and neutral soils (Table 3).

It is economically sound to maintain (through the regular liming) the soil reaction close to neutral or slightly acid.

Steady favorable soil reaction promotes stabilization of soil productivity on a high level owing to more effective utilization of fertilizers, and improved hydro-physical properties of soils. Liming substantially enhances general microbiological activity, mineralization of organic substance is accelerated, and absorption of atmospheric nitrogen by nodule and free-living bacteria is more efficient. Nitrobacteria, nitrogen-fixing bacteria and soil enzymes are more active in soils with the reaction close to neutral (pH_{kcl} 5,5 to 7,8).

Table 3. Optimum levels of pH_{kcl} for main agricultural crops

Crop rotations	Soil texture			
	Sand and sill	Light- and semi-loam	Heavy-loam and clay	Peat
Field crop rotation with large areas under flax and potatoes	5,0-5,3	5,4-5,6	5,5-5,8	4,6-4,8
Field crop rotation with perennial grasses	5,3-5,5	5,5-6,0	5,8-6,2	4,8-5,2
Fodder crop rotation (by-farm)	5,5-6,0	5,8-6,0	6,0-6,2	5,0-5,4
Vegetable and fodder crop rotation	5,8-6,0	6,0-6,2	6,2-6,5	5,2-5,6
Cultural hayfields:				
Cereals	5,2-5,4	5,4-5,6	5,6-5,8	4,6-4,8
Legumes and cereals	5,4-5,6	5,6-5,9	6,0-6,2	5,0-5,2

At present optimum liming rates are calculated on the basis of several factors: the crop rotation type, watering terms, soil texture, humus content and available forms of phosphorus, etc.

The Center of Agro-Chemical Service "Leningradsky" offers its recommendations on liming as well as calculation of liming rates and issuing of all necessary documents.

Repeated liming is required as over time calcium and magnesium leach out from soil or are taken up by plants, and the limed soils become acidic again. Lime works in soil for 5 to 15 years after the full dressing, depending on the soil type. On soils where the first liming provided the optimal soil acidity, low amounts of lime (400 to 1200 kg/ha) are recommended for application once in two to three years to maintain this acidity level (the so-called supporting liming).

Liming is growing in importance on forage lands of heavy use, where higher quantities of acid-forming mineral fertilizers are applied. To eliminate their acidifying effect compensatory liming is required (Table 4).

Table 4. Compensatory lime application rates

Kind of fertilizer and rate of 100 kg/ha	The lime application rate, 100 kg/ha
Ammonium sulphate	1,25 - 1,40
Ammonium saltpeter	0,75
Calurea	0,80 - 0,90
Anhydrous ammonia	1,50
Ammonia solution	0,30 - 0,40

Liming materials and their environmental assessment

Agricultural liming materials include commercial ground limestone, dolomitic limestone, industrial waste, and local calcareous materials. Lime-containing wastes (by-products) are steel mill slag, coal ash, chemical chalk, phosphate slag, slate ash, and others.

Along with calcium and magnesium, calcareous materials contain other elements, heavy metals included. Prior to application any calcareous material is to be tested for calcium and magnesium content (to determine the appropriate application rates), and for heavy metals and toxic compounds content (to verify the applicability and limitations).

Since there is a risk of environmental contamination with different toxic compounds from applied liming materials, the following ecological limitations and standards have been established:

- Mandatory availability of the quality certificate of the liming material.
- It is prohibited to apply lime immediately after the soil has been treated with chlorine-organic pesticides; the interval should be above 72 hours.
- It is prohibited to apply lime in any form and way to soil within the first sanitary protection zone around the freshwater sources.

- It is prohibited to apply lime within the second sanitary protection zone around the freshwater sources.
- It is prohibited to apply calcareous industrial wastes, which contain heavy metals, nuclides and other toxic substances above the maximum allowable concentration (MAC).

Depending on the content of heavy metals and other toxic substances all liming materials are divided into three groups (Table 5).

Table 5. Ecological restrictions for application of lime materials

Group number	Limitations for application	Types of liming materials
1	Liming materials, which are allowed for application without any restrictions	Limestone, dolomitic limestone, chalk, wastes of sugar beet production
2	Liming materials, which are allowed for application in the rates under 7 t/ha once in five years	Ferro-chromium slag, waste chalk, coal ash
3	Liming materials, which are prohibited for application	Materials in which the content of heavy metals, nuclides and other toxic substances exceeds MAC

2.2. Types of tillage

Soil cultivation is one of the most power-intensive operations in agricultural practice. Essentially, the depth, frequency and time of soil cultivation may impact on the interrelations between the cultivated lands and the environment.

Mechanical soil tillage eliminates weeds, diseases and pests; plant residues are incorporated, and physical and chemical soil conditions, favorable for the growth of crops, are provided. The soil tillage is usually combined with application of organic and mineral fertilizers; sometimes pesticides are also added.

Repeated and most intensive soil tillage is used when growing potatoes and root crops. The lands under these crops, however, account for only about 2,5 % of the arable area in Leningrad Oblast.

Traditionally grain crops are sown after the preliminary plowing (autumn or spring) and the subsequent cultivation. However, recently a more environmentally friendly and less energy- consuming method was offered, namely direct sowing. This method is widely applied in Finland, where it provides up to 60 % of the fuel economy.

Above 85 % of the arable land is occupied with perennial grasses. These lands should be used for no more than three to five years running, and then they are to be re-plowed and sown with other crops or grasses again.

Optimal time for spring soil tillage depends on the soil texture and soil moisture content that determines soil maturity. Optimal soil moisture content varies from 60 to 80% of the full retention capacity. The best conditions are provided at the average moisture content values within this interval. The optimal tillage period is shorter for heavier soil. Sandy soil does not tend to become compacted and to grow pulpy, but it cannot be tilled straight after a rain fall.

Spring ploughing may not be acceptable for the following reasons:

- 15 -17 cm deep soil layer may come to physical maturity after the optimal sowing terms are over;
- arable layer may get dry after plowing, then the sown seeds will not spring up for a long time;
- spring plowing requires agricultural machinery, which performs plowing, seedbed formation and sowing at a single run. There is still a big lack of such machinery on the farms.

The suitable time period for soil tillage in autumn is longer, but the delay in tillage is somewhat risky, because it may start raining, and the soil may become over-wet. After the early tillage, mineralisation of organic matter begins in soil. The formed nitrates may leach when the rainy period starts. Therefore the soil, which is tilled after the harvesting of the main crop, has to be sown with a catch crop.

There is no soil tillage method, which could be suitable in every case. Every crop in the rotation requires particular soil tillage depending on biological peculiarities of the crop. Soil tillage systems are developed for every group of crops (winter crops, spring cereals, root crops and potatoes).

Depending upon the type of farmland and the state of its surface, initial cultivation of the virgin soil includes plowing, rotary tilling or disking.

Plowing should be carried out with the complete soil overturning. Poorly grassed meadows and lowland bogs with older peat are plowed in autumn. Well-grassed meadows and lowland and transitional bogs with younger peat are plowed in summer or early autumn. The overturned layer is crushed right after the plowing. Sod-podzolic soils are first plowed to a full depth of the humus layer; peat-boggy soils are plowed to a depth of at least 25 to 30 cm.

Heavy disk harrows are used to cut the layer and make the surface of the plowed virgin soil loose.

Rotary tilling is an efficient way of cultivating hayfields and pastures with lots of hummocks and rough surface, drained peat bogs, and dry valleys with a shallow humus layer, if there are no big fibered roots and stones in the arable layer.

To prepare the virgin soil for a crop, two field passes of a rotary tiller are required. The first rotary tilling is carried out to a depth of 10 to 12 cm, and on the rough lands to a depth of five to six cm lower than the hummock basis, without a raker. The second rotary tilling is performed after 10 to 15 days with a raker to a depth of 15 to 18 cm.

Dry valleys with plenty of stones or dry valleys with a shallow arable layer and free from stones are tilled without plowing by loosening the sod surface. For this purpose, in the first case a heavy disk harrow and a disk plow are applied; and in the second case a rotary tiller for bogs.

In cereal and vegetable crop rotations systems with different tilling depths are applied. The soil for cereal crops is tilled to a depth of 12 to 16 cm; the soil for vegetables and potatoes is tilled to a depth of the arable layer of 22 to 24 cm. In case there is a well-developed plow pan or impermeable horizon, the regular chisel loosening down to 26 to 28 cm is recommended.

Pre-seeding tillage should contribute to weed control and formation of high quality texture. It is necessary to reduce the number of machinery passes (one to two) as they may destroy soil aggregates valuable for crop agronomy and lead to over-compaction of soil.

It is necessary to improve the tilling quality instead of increasing the number of machinery runs over the field!

Soil tillage on slopes has its own specific features, which contribute to erosion control. The highest yields on hilly terrain are obtained if the slopes covered with light and medium loam soils are plowed to 20 to 25 cm depth. During the deeper plowing the clay particles are brought to the surface, and this impairs water permeability of soil and intensifies soil erosion. Stones do not allow plowing and loosening of soil at the same time; therefore, it is not recommended to till the soil in this way. Deep plowing of thin soils on slopes is recommended only once in three years. Very shallow plowing (to 10 cm depth) stimulates water erosion on the hills to the utmost. Plowing the slope soils should be carried out to the normal (20 cm) depth.

In hilly terrain it is recommended to replace the mould board plowing of soil in autumn by soil loosening with the heavy-duty cultivator (chisel) to a depth of 20 to 22 cm two to three weeks after the stubble was sprayed with herbicides.

The heavy-duty cultivator (chisel) reduces water erosion 1.6 times compared with plowing. Energy consumption is also significantly smaller.

On the sloping lands exceeding three degrees the basic tillage is performed across the slopes. On erosion-exposed sites the autumn plowing of the arable land is to be avoided.

2.3. Erosion control

Erosion is a process of soil destruction under the influence of wind and water. The extent of soil erosion and damage depends on many factors, such as land configuration, type of crop, soil texture, intensity of irrigation or precipitation, soil fertility, soil cultivation systems, etc.

Loss of soil and organic matter due to water erosion can be very high (Table 6).

Table 6. Loss of soil and organic matter due to water erosion t ha^{-1} year^{-1}

Extent of soil erosion	**Loss of soil mass (%)**	**Loss of humus (sod-podzolic soils)**
Slight	**< 6**	**< 0.1**
Moderate	**6 – 12**	**0.1 – 0.2**
High	**> 12**	**> 0.2**

In Finland the average loss of farmlands due to erosion (all types of use) is 650 kg soil/hectare/year.

According to generalised data of research institutions the lost yield on slightly, moderately and highly eroded soils is 10 to 20%, 30 to 50%, and 60 to 80%, respectively.

One of the key reasons of this negative process is that agricultural producers fail to follow scientific principles and laws of farming.

The basic measures to prevent soil erosion and, consequently, the loss of nutrients are as follows:

1. Introduction of scientifically substantiated, site-specific crop rotations, which are designed with the due account for the erosion risk.
2. System of erosion-preventive tillage: subsoil, minimum, contour, chisel tillage, soil slitting, etc.
3. Introduction of contour, terrace, and strip cropping and combined measures for soil improvement and erosion control.
4. The use of stubble crops and compact sowing of soil-conservative crops in inter-row space of the main crop. This method is especially effective on light soils.
5. Grassing of badly eroded lands.
6. Good agricultural practice – correct type, rate, time and technique of application of mineral and organic fertilizers is an important measure to prevent leaching and run-off of nutrients from the fields.
7. Application of polymers to improve the soil structure.

2.4. Optimal nutrition of fodder crops

The basic principle of agrochemistry is that abundance of one nutritive element cannot make up for a deficiency in another.

In the course of their development the plants uptake big amounts of nutrients (nitrogen, phosphorus, potassium, calcium and others).

Application of fertilizers is targeted to:

- creation of optimum conditions for mineral nutrition of plants;
- maintenance of nutrients balance in soil.

Regular (every four to five years) agrochemical surveys are the basis for calculation of fertilizer application rates. Humus content, available forms of phosphorus, potassium, microelements as well as soil acidity are determined. Depending on the concentration of available forms of phosphorus and potassium, the soils of the Non Black-soil (Non - Chernozem) zone of Russia are divided into six classes (Table 7). Efficacy of mineral fertilizer application rates depends directly on the content level of nutritious elements introduced with the fertilizer. Phosphoric and potash fertilizers are highly effective on soils with low content of mobile forms of these elements; and almost do not provide crop yield increment when applied on high-fertile soils, with increased and high content of mobile forms of phosphorus and potassium. However, if these fertilizers are not applied regularly, even the high-fertile soil will start to gradually degrade.

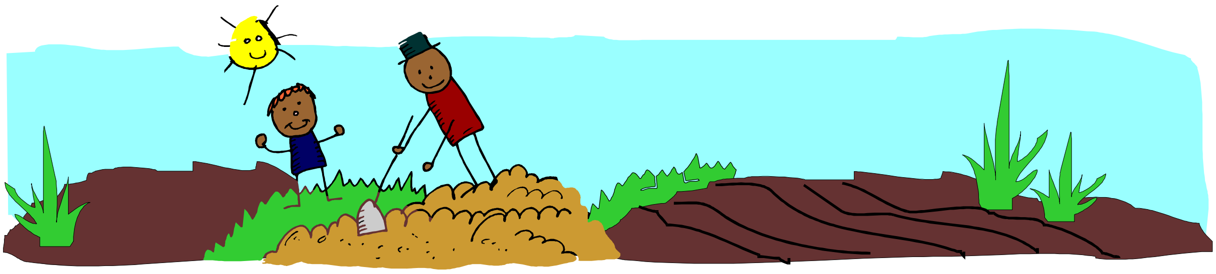


Table 7. Soil classes by content of available forms of phosphorous and potassium

Class	Content	Mobile P_2O_5	Mobile K_20
		mg per 100 g	
I	Very low	<2.5	<4.0
II	Low	2.6-5.0	4.1-8.0
III	Moderate	5.1-10.0	8.1-12.0
IV	Increased	10.1-15.0	12.1-17.0
V	High	15.1-25.0	17.1-27.0
VI	Very high	>25.0	>25.0

From the standpoint of economic soundness and environmental safety, application of fertilizers should be planned in such a way that only small residues of nutrients, which will be washed out later, are left in soil after the harvesting. Especially this concerns nitrogen fertilizers. Higher quantities of nitrogen may result in excessive accumulation of nitrates in the products, on the one hand, and nitrogen export from the soil, on the other.

Nitrogen as a nutritious element is in the first minimum in our soils. It is a component of proteins, chlorophyll, enzymes and other organic compounds of a plant cell. Under sufficient nitrogen supply plants develop dark-green strong stems and leaves; they grow very well and give very high yield. However, surplus of nitrogen nutrition in the second part of the vegetation period delays maturing; the plants develop a lot of biomass and too little of grain or tubers.

Total nitrogen stock in the arable layer (0 to 25 cm) of sod-podzolic soils ranges from 0.05 to 0.2% corresponding to 1 to 6 t ha^{-1}; it is mainly present in weakly decomposed humus substances. The major source of nitrogen for plant nutrition is its mineral compounds, salts of nitric acid and ammonium. The total supply of mineral nitrogen compounds in the soil is 1 to 5 % from the total nitrogen stock. This figure is changing significantly during the vegetative period. In ordinary agrophytocenosis the maximum amount of mineral forms of nitrogen in the soil is found in the beginning of summer, after the application of fertilizers and as a result of microbiological mineralization progress. With the development of the farm crop, the stock of mineral nitrogen in the soil runs short, and achieves the minimal values by the end of July - beginning of August. Prior to and immediately after harvesting, the content of mineral forms of nitrogen in the soil may increase.

The loss of nitrogen from soil is caused by:

- uptaking by plants and export with the yield;
- unproductive loss due to washing away, denitrification and emission.

Nitrates are ready soluble in water, they are not fixed in soil. Leaching of nitrates with precipitation and drainage water is a widespread phenomenon. Average amount of leached nitrogen may be as high as 10 to 20 kg/ha, but in some cases it may reach 80 kg/ha. From the soil, the nitrates get to the ground water and surface water systems.

The amount of nitrate leaching depends on weather conditions and total nitrate stock in the soil; the latter depends on the soil tillage, whether the field is covered with vegetation or rests. The soil texture plays a considerable role in the flow of nitrates. Sand soils lose nitrates easier than loam soils.

Considerable loss of nitrogen from soil occurs in a gaseous form during the denitrification process. To avoid nitrogen depletion in soil and to obtain high yields of agricultural crops it is necessary to enrich the soil with nitrogen constantly. One of the natural sources of nitrogen is atmospheric nitrogen. There is around 80 thousand tons of nitrogen in the air above every hectare of land surface, but molecular nitrogen from the air is not available to higher plants.

There are three ways of nitrogen restock in soil:

- with precipitation (up to 5 kg ha^{-1})
- air nitrogen fixation by free-living bacteria (up to 10 kg ha^{-1})
- nitrogen fixation by nodule bacteria of legumes (up to 250 kg ha^{-1})

Free-living nitrogen-fixing soil bacteria are able to accumulate annually 5 to 10 kg N per ha under favorable conditions. The amount of nitrogen accumulated depends on leguminous plant species. Clover is able to accumulate 150 to 160 kg, lupine – 160 to 170 kg, alfalfa – 250 to 260 kg, pea – 70 to 80 kg N per ha. To obtain the yield of 2000 to 2500 kg ha^{-1} of winter wheat it is necessary to apply 20 to 60 kg N per ha.

Leguminous perennial grasses are able to supply 2/3 of N requirement fixing it from the air, and only 1/3 of N is supplied from the soil. In mixed grass canopies the cereals use nitrogen of legumes after nodules atrophy. The grain crops have the greatest need of nitrogen fertilization (spring and winter wheat, then oat, perennial grasses, and in a lesser degree barley and rye).

In recent years optimization of nitric fertilizer application rates by the mineral nitrogen content in soil is prevailing, especially when spring soil diagnosis is performed. Soil nitrogen supply is estimated according to the accepted grouping (Table 8). Soil samples are taken from the arable layer in spring, when the soil is warm enough.

Average stock of 90 kg of N per ha in spring is estimated sufficient for most of the crops. Nitrogen split fertilization in critical stages of plant development combined with organic fertilizer application is found most efficient.

Table 8. Soil groups by nitrogen content

Content of mineral N in soil	**$N – NO_3$ + $N – NH_4$, mg kg^{-1}**
Very low	**Less than 5.0**
Low	**5.1 - 10.0**
Moderate	**10.1 - 20.0**
Good	**20.1 - 40.0**
High	**Above 40.0**

Heavy nitrogen fertilizing is not recommended. If more than 120 kg/ha of nitrogen are applied at a time in rainy weather, nitrates concentration in leakage water may reach 8 to 17 mg/L, and even more. When N_{60} is applied, concentration of nitrates varies from 2 to 7 mg /L. Under conditions of our climatic zone, application of nitric fertilizers in anticipation of their after-effect is not justified since most mineral forms of nitrogen, staying in soil after the crop harvest, will be lost in autumn through washing out and denitrification.

The top dressing of nitric fertilizers in early spring may pose a certain environmental threat due to the surface runoff on frozen soil.

One of the tasks in optimal mineral fertilization of hayfields and pastures is biochemical composition control of forage. Fertilizers, depending on their formulas and application rates, can have both positive and negative effects on produced forage quality. The optimum protein level in grasses is observed when 120 to 210 kg N per ha are introduced with fertilizers. If application rates are increased up to 200 to 250 kg N per ha, there is a risk of excess concentration of nitrates in forage.

Split application of fertilizers, lightness, availability of water and microelements, the soil reaction affect greatly the nitrates content. Sharp deficiency of potassium along with high level of nitrogen can also result in excess concentration of nitrates.

Good quality forage with nitrates content below maximum allowable concentration (MAC) may be obtained if 180 to 240 kg N per ha (three to four grazings) are applied on non-irrigated lands. This is an important restriction when defining maximal fertilizer application rates. Application of above 60 kg/ha N for each grazing will result in exceeding of MAC.

Extra care should be taken when applying nitric fertilizers close to the wells and on the land where the subsoil waters are formed. Protective belts, where fertilizers are not applied at all, should be left around the water intake points.

The schedule of phosphoric fertilization is an integral part of the soil survey report. The basic application rates of P fertilizers should be as follows: for cereals and grasses – 35 kg, for annual grasses grown for silage – 70 kg, and for potatoes – 90 kg P_20_5 per ha per year. These values may vary with the outcomes of soil fertility analysis.

On soils with low mobile phosphorus content, the biggest in our region, crop yield increments were obtained at the application rate of phosphoric fertilizers of 90 kg of active substance per hectare. The amounts of 30 to 60 kg per hectare are recommended for soils with moderate phosphorus content, and on soils with high mobile phosphorus content these fertilizers are not effective. On soils rich with phosphorus it is necessary to use phosphoric fertilizers only according to the norms of minimum amounts necessary for plants.

Unlike nitrogen, phosphorous is not leached from soil to the ground water in large amounts, as most of its mineral compounds are slightly soluble. According to Finnish experiments only one to two kg P/ha may leach depending on soil type and crop, mainly with surface runoff when the snow thaws or it rains heavily. For 3000-3500 kg of hay dry matter (grass-legumes mixture) per ha it is necessary to apply 20-40 kg P per ha.

Organic compounds of phosphorus are better dissolved and easier mineralized. Such compounds are found in both animal waste and some detergents. Phosphorus compounds cause eutrophication of water systems. There is a high risk of P leaching

from potato and vegetable fields sloping to a water source. Phosphorus runoffs are always bigger after surface fertilization compared to subsoil application.

Surface fertilization of perennial grasses can be minimized by fertilization “in reserve”, which means application of increased quantities of P fertilizers prior to re-sowing of grasses. In this case only N and K fertilizers are to be applied every year. Phosphorus is introduced only in spring during the first additional fertilizing. During the second and third additional fertilizing phosphorus is not used at all.

The key indicator of sufficient potassium supply for plants is the content of exchangeable potassium in the soil. Investigations have shown that mobile K concentration of 10 to 15 mg K_2O per 100 g soil and application of moderate amounts of K fertilizers (60 to 90 kg K_2O per ha) guarantees 3 to 5 t ha^{-1} of grain units yield of crop rotations on sod-podzolic soils.

The average content of potassium in cereal grasses is close to optimum zoo-technical norms. It is inexpedient to increase the one-time application rates of potash fertilizers above 90 kg on rich in potassium soils, and above 120 kg on soils with low potassium content meeting the hygienic requirements to forage quality for cattle. Otherwise the potash content in forage will exceed 3 % (maximum allowed concentration). High level of potash fertilizing, especially combined with high level of nitric one, exposes the animals to diseases caused by low contents of magnesium in the blood. For the same reason it is not necessary to spread potash fertilizers on hay fields and pastures to reserve year after year.

K is less mobile than N, and considerably more mobile than P, especially in the light soils. However, K is not a risk element for eutrophication and pollution of the environment. Nevertheless most of K fertilizers contain chlorine. The negative chlorine impact on plants can be avoided by applying chlorine-containing K fertilizers in autumn simultaneously with plowing. In spring it is recommended to use chlorine-free K fertilizers, such as chlorine-free azophoska and ammophoska universal.

Complex fertilizers have some advantages over simple fertilizers. They supply better plants with nutrients; and the expenses on their transportation, storage and application are much lower.

The leading role in the variety of complex fertilizers belongs to those which have the equal ratio of nutrients (1:1:1). These are nitrophoska, nitroammophoska, azophoska and carboammophoska. These fertilizers are widely used in the Non Black-soil zone of the Russian Federation, where both nitric, phosphoric, and potash fertilizers are effective. On light soils the fertilizers with nutrients ratio of 1:1:1 are applied prior to sowing for spring grain crops, potatoes, red beet and annual grasses. On heavy soils these fertilizers are applied in autumn.

A big share in the range of complex fertilizers belongs to those in which P or both P and K prevail over N (1:1.5:1 and 1:1.5:1.5). These fertilizers are (NPK), ammophoska universal, diammophoska. They are especially effective for fertilizing winter and spring grain crops, potatoes, fibre flax and perennial legumes cultivated on soils with low K and P content.

An important place in the range of complex fertilizers is occupied by those in which N prevails over P and K (1.5:1:0; 1.5:1:0; 1:1:0.5). These are different kinds of nitrophoska, nitroammophoska and azophoska. They are applied mostly under forage crops – silage crops, annual grasses, hayfields and pastures.

Lately various organic and mineral complex fertilizers have appeared which contain micro- and macroelements, and humus substances. In these fertilizers mineral elements are bound with humus substances, making N and K less mobile, and P easier available for plants. These fertilizers dissolve very slowly, and supply

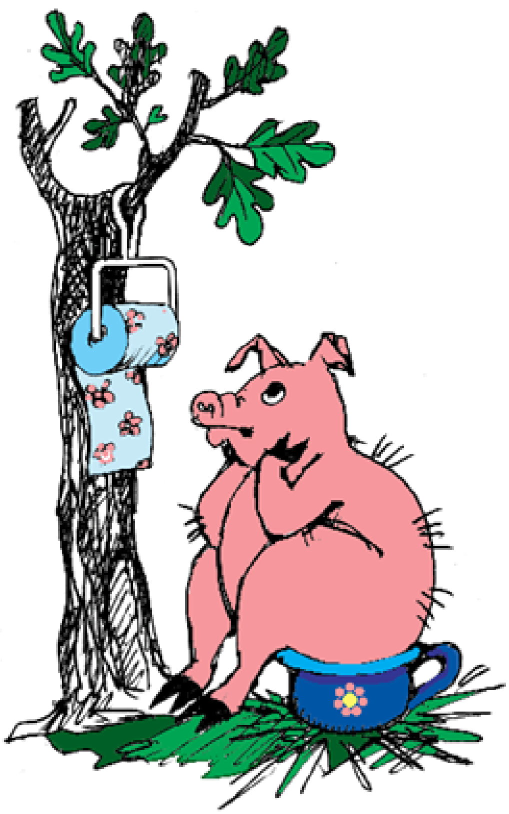
plants with nutrients during the whole vegetation period. Nutritive efficiency of organic and mineral fertilizers is as high as 90 to 95 %.

The ready soluble complex fertilizers, which contain all macro- and microelements, have become more popular. These are «Rastvorin» and «Akvarin». They are very effective for fertilizing and top dressing of plants as well as for application in the systems of drop irrigation.

2.5. Environmentally friendly use of organic fertilizers

Soil fertility plays a pivotal role in increasing farm crop yields. The challenges of maintaining, efficient use and restoration of soil fertility are addressed at the national level. In 1998 the Federal Law "On Soil Fertility" (№ 52, dated 10.05.1998) was adopted, and in 1999 the Law of Leningrad Oblast "On State Regulation of Agricultural Land" (№ 15, dated 15.07.1999) came into force.

The basis for high crop yields and soil fertility is the application of organic fertilizers (manure).



Organic fertilizers enrich the soil with nutrients and also make it looser, improve its moisture and air regime. They provide all nutritious elements needed by plants.

Organic fertilizers also improve physical and chemical conditions of soil; raise the nutrients stock; reduce the acidity; increase the content of absorbed alkali; enhance absorption, buffer and water capacity of soil as well as infiltration of water.

Organic fertilizers enrich the soil with micro flora, which strengthens the activity of useful microorganisms and improves the crop supply with carbon dioxide. It is recognized that there is a positive effect of organic fertilizers on binding the heavy metals and nuclides in soil as well as on self-cleaning of soil from chemicals and improvement of its phytosanitary condition.

Organic fertilizers not only contribute to higher crop yields, but they also improve the quality. On the other hand, improper preparation, storing, and use of organic fertilizers, as well as excessive application rates, may cause the dramatic degradation of their performance and have an adverse effect on the environment.

Nutrient loss takes place on each stage of manure handling – from manure removal to land application: on the farm, during the storage, transportation and soil incorporation. The greatest losses are those of nitrogen, the most important plant nutrient. Nitrogen may emit in the form of ammonia or in nitrate or organic form. Phosphorus is lost through leakage during improper storage or with the surface run-

offs after its soil application. Potassium is lost in the light soils if untimely applied at high rates.

On sod-podzolic sandy and loamy sand soils the positive effect of organic fertilizers on crop yields is observed for as long as three to four years. On light loam and clay soils this effect stays for up to six to eight years, and on heavy clay soils up to 10 to 12 years. The crop yield premiums owing to organic fertilizers in the first year are 20 to 40 % from the overall increase per crop rotation.

It is recommended to apply organic fertilizers on two or three fields in each crop rotation in a three to four year cycle on sandy and sandy clay soils, and a five to six year cycle on loamy and clay soils.

Organic fertilizer application rates, dates and techniques depend upon their type, soil and climatic conditions, and biological specific features of the crops.

When calculating application rates of organic fertilizers, deficit-free humus balance should be provided for soils with sufficient humus content, and positive humus balance should be provided for soils with low humus content with the aim to ensure the optimal humus content for the whole crop rotation.

Following HELCOM Recommendations the efficiency of manure application should be improved by determining the ceiling limit of 170 kg of nitrogen per hectare per year.

In case of insufficient availability of organic fertilizers on the farm, lower application rates (with due account for mechanical application mode) on bigger areas are recommended.

When calculating the application rates of organic fertilizers, which may contain heavy metals or other pollutants (sewage sludge, municipal garbage, etc.), it is advised to strictly follow environmental requirements in compliance with applicable regulations.

Application of organic fertilizers together with autumn ploughing is considered the most efficient.

Nutrient loss from organic fertilizers causes pollution of surface and ground waters with nitrogen and phosphorus resulting in eutrophication of water systems, and atmosphere pollution with toxic gases (hydrogen sulphide, ammonia, and methane), which may be the reason of acute poisoning. According to the monitoring carried out by the Federal State Organization “Centre of Agro-Chemical Service “Leningradsky” in 2004, the contribution of biophil elements from farming lands is seven to nine kg of nitrogen per hectare, and 0,6 to 1,1 kg of phosphorus per hectare.

In Leningrad Region organic fertilizers should be applied according to the recommendations on their efficient use, with due account for site-specific conditions and in strict compliance with agro-technical, sanitary and environmental requirements set in applicable regulations and reference materials, for example, “Scientifically substantiated manure application in Leningrad Oblast” (published by the Russian Academy of Agricultural Sciences in 1987), “Scientifically substantiated technology of fertilizers and lime use” (published by North-West Research Institute of Agricultural Engineering and Electrification – SZNIIMESH in 1997), “Drawing a fertilizer application program” (published by the Agriculture Ministry of the RF in 2000) and others.

According to the standard СП 1.2.1170-02 “Hygienic requirements to safety of agro chemicals” organic fertilizers should:

- be disinfected and be free from any pathogenic flora;
- come from the farms which are considered safe from the standpoint of occurrence of diseases common for people and animals (poultry).

In the regulation on each type of organic fertilizers, nutrient content description should include both total nitrogen and nitrates content.

All regulations and recommendations elaborated for nitrogen-bearing fertilizer application should be calculated in the way to avoid accumulation of nitrates in the crops above MAC.

2.5.1. Manure and manure-based composts

Manure is a basic organic fertilizer. Daily production of solid and liquid excrements per one animal unit (cow) is around 40 kg equivalent to approximately 14,6 tons per year. Half of this amount is left on the pastures and around seven to eight tons may be processed. Half-decomposed manure obtained after leak-proof (compact) storing is considered the best organic fertilizer. The loss of nitrogen in the form of ammonia is the highest during manure decomposition. Loose storage of manure may cause phosphorous loss in the form of hydrogen phosphate.

Manure composting decreases substantially the lifespan of weed seeds, worm eggs and other pathogenic flora.

Chemical content and nutrient capacity of composts depend greatly on the type of manure, the animal, consumed feed, amount and type of litter, storing terms and methods.

Application of composts compared with the separate application of basic components allows:

- to lower nutrients loss, e.g. ammonia nitrogen in the first place;
- to avoid environmental pollution with manure-contaminated wastewater;
- to improve drastically the uniformity of nutrient supply across the field;
- to cut the number of tractor/implement runs across the filed thus avoiding over-compaction of soil;
- to increase reliability and lifetime of machines for fertilizer application;
- to avoid introduction to the soil of non-desirable impurities, which may be found in manure.

Compost should be applied under the row crops (vegetables, feed roots, potato, maize, and sunflower), winter cereals, when establishing or renovating hayfields and pastures, and to reclaim meliorated lands.

Application rates of organic fertilizers differ with the humus content in soil, soil texture, biological needs of grown crops, and nutrient value of the compost. Application rates of mineral fertilizers are calculated with account of the amount of nutritious elements introduced with organic fertilizers.

Composts are used in different periods of time depending on the crops, but the best season is autumn.

Organic fertilizers could be applied in two ways – with a plow (deep incorporation) and with a disk cultivator. On heavy soils the composts should be incorporated with the cultivator to a depth of 12 to 15 cm. For winter crops they are applied under the crop occupying the fallow, for row crops they are applied in autumn or spring.

On light soils, however, organic fertilizers should be incorporated to a depth of 22 to 28 cm (full cultivation depth) as close to the date of sowing as possible, especially for winter crops.

No later than two hours after spreading the organic fertilizers over the surface of the field, further soil incorporation is applied to avoid nitrogen loss, e.g. in the form of nitrogen ammonia in the first place. Good results may be obtained with the deep incorporation of higher quantities of fertilizers with the double-deck plough.

2.5.2. Liquid manure (slurry)

Under the loose animal housing system several types of manure are obtained depending on the moisture content:

- semi-liquid manure with less than 92 % moisture content;
- liquid manure with 92-97 % moisture content;
- manure- contaminated wastewater with more than 97 % moisture content.

Manure not mixed with water and litter material (mixture of excrement and urine) has around 88 to 89, 5 % moisture content.

Nutrients (N, P, K) and dry matter content in liquid manure depends upon the way of cleaning the barns and type of animals.

Liquid manure application rates are calculated depending on the plant requirements in nitrogen. Higher application rates of liquid manure result in lower yield quality, poorer biological properties of soil, and environmental pollution with nitrates.

When calculating application rates of liquid manure the following should be taken into account:

- Soil type and nutrients content
- Nutrient need of the crop
- Preceding crop
- Amount of accumulated slurry and transportation distance to the fields

Liquid manure is applied in three ways: on the field surface with further soil incorporation, subsoil application, and watering. The most efficient and environmentally safe way is subsoil application, which reduces drastically nutrients loss, e.g. nitrogen in the first place. Subsoil application of liquid organic fertilizers increases feed crops yield by 10 to 15 % plus, and decreases 7 to 10-fold nutrients loss by avoiding surface leakage of fertilizers and ammonia nitrogen emissions. This also contributes to

lower environmental pollution.

When being used for watering, liquid manure is separated into fractions immediately after the quarantine period.

Semi-liquid manure is used for compost production or for surface application with the further soil incorporation.

Liquid manure application on pastures and grasslands requires double-fold lower application rate if the legume crops content in the grass mix is high. On pastures, liquid manure is best applied before or after vegetation of grasses. It may be applied on pastures 25 to 30 days prior to the next grazing. Later application can cause lower palatability of grass, so the pastures should be fertilized just after the grazing.

Maximum permissible application rate of manure is calculated by the nitrogen content required for estimated crop yield with the corresponding compensation by using mineral fertilizers with phosphorus and potassium.

The preferable time to apply liquid manure is autumn and spring-summer. Autumn application with plowing is considered the most effective. When applying liquid manure during the vegetation period it is necessary to observe a waiting period from the last application to the harvest or yield use (State Standard – ГОСТ 26074-84).

To avoid possible nitrogen loss due to denitrification in soil and topsoil leakage in the form of nitrates, it is recommended to use inhibitors of nitrification. The optimum inhibitor content is 0,5 % of active ingredient from the nitrogen application rate in the fertilizer.

It is prohibited to apply liquid fertilizers in water protection zones of fish-breeding ponds, rivers and enclosed water bodies.

To protect the environment the following rules are to be observed:

1. Organic fertilizers are not to be applied on the snow cover or frosted soil; applied fertilizers should be incorporated into the soil immediately.
2. Organic fertilizers should be applied in scientifically substantiated quantities, which meet the needs of crops with the due account for soil fertility.
3. Liquid manure is to be disinfected by chemical or biothermal methods.
4. Animal waste should be composted with desiccants rich in carbohydrates.
5. Liquid manure is not to be applied on floodable parts of arable lands.
6. Organic fertilizers should be applied with the due account for the surface relief in combination with soil conservation tillage.
7. It is strongly recommended to use widely the techniques, which provide biological binding and fixing of nitrogen in organic compounds (catch crop sowing, use of soil microflora).

The use of organic fertilizers (preparation, transportation, application) is cost-intensive. Gained yield premium owing to organic fertilizers application has to cover the expenses on their use. The advantage of organic fertilizers over mineral fertilizers is also their long-term after-effect in soil.

2.5.3. Green fertilizing

An important fertilizer and a source of organic matter in the soil is *the green manure* (siderates); consisting of growing farm crops for green mass production to be incorporated into soil. This is one of the most efficient ways to improve soil fertility. Green manure is an effective and environmentally clean source of organic matter to increase the fertility of deficient in humus sod-podzolic loamy soils, and especially sandy soils. Green manure is widely used in organic farming.

Siderates could be leguminous crops (annual and perennial lupine, seradella, melilot, winter and spring vetch *(Vicia),* peas, lentil, sainfoin, clover, alfalfa and others) and some non-leguminous crops (mustard, winter and spring rape, winter ray, etc.)

Green fertilizers can be classified in three types:

1. Independent fertilizer: if a crop rotation field is occupied with legume crop since spring and during the whole vegetation period.
2. Intermediate fertilizer: if a siderate is sown for the period between harvesting of one crop and sowing of the other.
3. Mown fertilizer: if the plants are grown on the emergency field and green mass is transported to other fields and incorporated.

Basic scientifically grounded reasons to use green fertilizer:

- It is a remarkable source of humus and nitrogen in soil. When incorporated in soil, the green mass of siderates with the yield of 35 to 40 t/ha supplies 150 to 200 kg of nitrogen that is equal to 30 to 40 tons of manure. Use factor (first year) of nitrogen from the green fertilizer is twice as high as that of nitrogen from manure.
- It improves agrochemical, physical and chemical properties of soil: increases pH value, total absorbed alkali, and decreases hydrolytic acidity.
- It enhances the biological activity of soil, enriches the air with carbon dioxide to improve the nutrition of crops, and activates soil microflora.
- It kills phytopathogenic fungi and promotes the development of saprophytic microorganisms.
- It protects the environment from pollution. Intermediate siderates, grown in autumn and spring between the main crops in the crop rotation, prevent the leakage of nutrients from the topsoil. They also protect the topsoil from wind and water erosion.

Annual lupine is a popular siderate of special importance. It can be used in three ways:

1. Green mass of lupine is harvested for silage, the roots and stubbles are incorporated as a fertilizer under the winter crops.
2. The forage lupine is grown and harvested for grain, the straw and roots are incorporated in the soil.
3. Budding or blooming green mass is cut for forage and the sprouted aftermath is incorporated.

The green manure is an important factor of increasing soil fertility and environmental protection. This agro-technical method allows for savings in mineral fertilizers and other chemicals, thus improving the economical performance of farms.


Annual lupine

2.6. Storage of fertilizers

Pesticides and agrochemicals are authorized to be stored only in the storehouses specially designed for that purpose. Bulk storage of pesticides is prohibited. When storing pesticides and agrochemicals, it is necessary to observe the requirements and eliminate the risk of harming the human health and natural environment.

Requirements to storage of pesticides and agrochemicals are defined by the Federal Executive Bodies. ***(Federal Law «On Safe Handling of Pesticides and Agrochemicals»)***

3. ENVIRONMENTALLY FRIENDLY FODDER CROPPING FOR CATTLE

3.1 Major feeds and their production technologies

Grasses of cultural pastures are the most high-grade and cheap forage.

It is necessary to reserve 0,4 to 0,5 hectares of pastures per one cow in summer. The summer grazing of cattle is a preventive and sanitary action to increase the animals' resistance, and to prolong their economic production life. Cattle should be taken to a pasture when the grass is 10 to 15 cm high. Cows must graze 6 to 8 hours a day. Water supply should be provided based on a cow's need of 60 to 120 litres of water daily, or five to six litres per one litre of milk yield.

Nutritional value of pastures depends, first of all, on the botanical composition of the grass, its development stage in the grazing period, and soil type. Meadows and pastures require fertilizing and weed control. It is recommended to let the cattle out to graze not earlier than 18 to 20 days after application of mineral fertilizers.

The best pasture grass species are Kentucky bluegrass, Meadow and Red fescue grass, Perennial (English) ryegrass, Timothy, Awnless Brome grass, Cocksfoot grass, and Meadow foxtail. The best pasture legumes are Red and White Clover, Birdsfoot (Trifoil), Alfalfa, Vetch, Pea, and Fababean. Some leguminous species are, however, sensitive to grazing of big cattle.

Legume-grass mixtures are considered to have the greatest nutritive value. To provide the maximal dairy efficiency, the yield of legume-grass mix in each grazing cycle should be six to seven tons. High quality pasture grass has 16 to 18 % of protein, and 15 to 26 % of dry matter. Under the conditions of Leningrad Region the grass lacks phosphorus, copper, sugar, cobalt, starch, essential amino acids, such as methionine, lysine and tryptophan, carotene, and vitamins A, D, E. Surplus of protein and potassium is found in spring grass, decreasing the level of magnesium in the grass. So magnesium should be included in the cow diet. During initial and final grazing periods the cows do not receive enough dry matter and energy from the grass. So they should be additionally fed with hay (two to three kg per head) and concentrates. To ensure efficient feeding of cows, continuing inventory of pasture grass stock, its chemical composition and nutritive value is required. By the end of the pasture period the productivity of pastures reduces more than double-fold, nutritive value becomes 30 to 40 % lower, sugar content – 60 to 75 % lower, but the

amount of cellulose grows from 20 % to 38 %. It should be kept in view that significant fluctuations in grass nutritive values might occur within each grazing cycle.

High quality hay plays an important role in efficient feeding of cattle. The lack of high-quality hay results in lower livestock yields and milk fat content, and decreased reproductive ability of the animals.

One kg of high-quality hay has at least 12 % of protein, 15 to 17 % moisture content, nutritive value of 0,5 to 0,6 fodder units, 70 to 95 g of sugar, 20 to 25 g of fat, 30 to 50 mg of carotene, and also the mineral salts, which the animals need badly: calcium, phosphorus, magnesium, sulphur, iron, copper, manganese, iodine, cobalt. It is very important that the hay contains nutritious and biologically active substances and mineral salts in the most favourable ratio for efficient feeding of the animals. During the stable period the cattle should receive daily at least one to two kg of hay per one kg of live weight for a normal exchange processes in the digestive tract.

To make high-quality hay the following technological basics are to be observed:

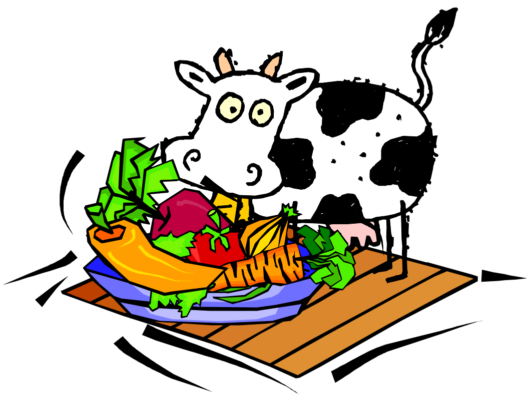
- beginning of grass harvesting: grass species – leaf-tube formation - beginning of earing stage, leguminous species – budding stage;
- end of grass harvesting: grasses and leguminous – prior to mass blooming period;
- priority in mowing: foxtail, cock's foot grass, timothy, leguminous-grass mixtures, grass on raised sites, legumes;
- the best time for mowing is at night and in the morning;
- the mowing height is 8 to10 cm from the field surface;
- duration of air-curing of cut grass in windrows is minimal, but if moisture content is 30 to 50 % additional drying with forced ventilation is necessary; if moisture content is 25 to 30 % when making the hay in bales additional drying with forced ventilation is necessary;
- additional drying with forced ventilation for 140 to 150 hours;
- normal (standard) moisture content of the dried hay is 15 to 17 %.

Haylage, as a kind of forage, is found between the hay and silage in feed classification. Haylage is prepared from perennial grass and legumes-grass mixtures, air-cured in swaths or windrows with up to 55 to 60 % moisture content.

High quality haylage should contain 0,35 fodder units in one kg, 14 to 15 % of protein in dry matter, 4 to 5 % of sugar, 40 to 50 mg of carotene, 28 % of cellulose and 0,1 % of butyric acid at most.

Silage has a big share in winter-feeding of cattle. High quality silage should contain 14 to 16 % protein in dry matter, and 28 to 40 % of dry matter.

Silage is better made of perennial grasses, grass-legumes mixtures, and corn. The harvest of forage plants should begin no later than the blooming stage starts. The storage should be filled with raw vegetative material during three to four days. A tractor should ram the raw material for at least 16 hours per day. Grasses harvested directly at an early stage have high moisture content (above 75 %). In this case in



order to preserve sugar and protein, biological or chemical additives are used to increase the acidity of silage as soon as possible.

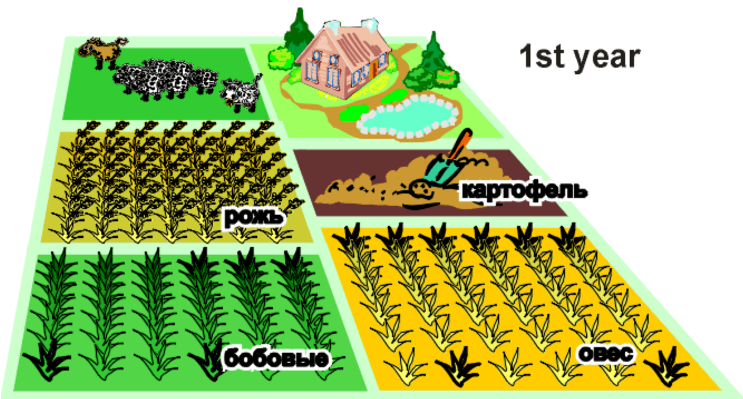
The effluent leakage from silage should be avoided in order to reduce dry matter loss and environmental pollution. The silage storing facility should be waterproof; it has to be designed and constructed in such a way as to avoid the risk of ground and underground water pollution. The silage should not be stored near rivers, nor in sanitary protective zones close to groundwater supplies. The silage can be stored in trenches or packed in polyethylene film in towers. Air-curing of grass in swaths prior to storing (up to 70 % moisture content) increases the water-soluble carbohydrates content in the dry matter, and good preservation of silage, which is less dependent on acidity level. Silage is ready to be consumed in two to three weeks. A cow can eat daily up to 25 to 30 kg of high-quality silage.

Cultivation of grain cereals allows making forage with big output of dry matter, high starch (up to 70 %) and fat content (up to 8 %). Protein content is about 9 to 10 %. Grain crops can both increase efficiency of dairy herd, and be ideal forage for meat breeds owing to rather low protein content and high energy content (up to 13 MJ/kg of dry matter).

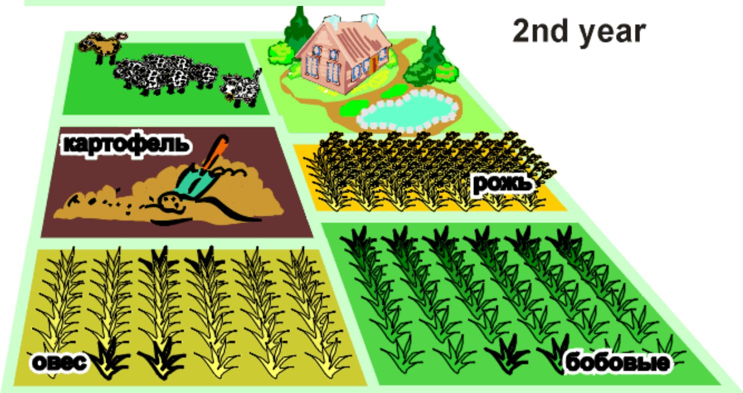
At present several kinds of grain forage with different nutritive value may be prepared:
- grain-haylage, the moisture content should be 55 to 65 %.
- crashed grain, the grain on milky stage may be harvested, moisture content is 40 %.
- traditional fodder grain, moisture content is 10 %.

Grain crops are a good supplement to grass silage in cattle diets.

3.2. Crop rotation



4 field crop rotation



A crop rotation is scientifically substantiated varying of farm crops and fallow lands in time and space on the farm territory, accompanied with the appropriate system of soil cultivation and fertilization to provide higher soil fertility and stable crop yields.

Agricultural producers define specific crop rotations according to their technical and economic circumstances and market situation. Certain agro-ecological rules should be observed for sustainable development of agricultural production and maintaining the existing balance in the «production-environment» system.

Crops themselves, grown in crop rotations, do not pose any threat to the environment. But

economically sound yields are linked with intensification of technologies, which may contribute to a certain extent to environmental pollution and degradation of some natural components.

To avoid the negative effects of crop rotations a number of general rules are to be observed.

Crop rotations with a big share of row crops (above 50%) should not be introduced on flood plain lands and on sloping lands exceeding three degrees.

Crop rotations should not include above 75% of grain and row crops.

On the fields, which are systematically re-used under grain or row crops, the catch crops are recommended to decrease activity of certain pathogens and to lower the washing out of mobile nutrients. For grain crops spring rape is most effective as a catch crop, for row crops rye is recommended.

Clean fallows are not advised in crop rotations as in fallows soil aggregate structure is damaged and migration of mobile nutrients beyond the arable layer becomes more active. Clean fallow may be included in the crop rotation pattern during one rotation only for taking away stones, applying high rates of organic fertilizers, liming and other land amelioration activities.

The crops, which restore the soil fertility, define the following crop rotations:

- Crop-changing – includes perennial leguminous grasses, which are the predecessor of winter crops,
- Grass rotation – includes perennial grasses, which are used before spring crops;
- Siderate – the crop grown as green fertilizer restores soil fertility.

By composition of cultural plants the following crop rotations are identified:

- Field crop rotations - the basic field crops are cultivated;
- Forage crop rotations – rich in forage crops;
- Vegetable crop rotations – besides proper vegetable crops they usually include potatoes, sometimes perennial grass and siderates.

When growing potatoes in a crop rotation the following should be taken into account:

- The best predecessors of potatoes are winter perennial leguminous, spring or grass mixes (annual leguminous and spring or winter crops); when growing potatoes on a layer of perennial grass usually spring subsurface loosening is performed;
- Heavy loams and over-compacted soils are not suited for growing potatoes;
- Continuous potato growing on the same field is not recommended (potatoes are to be planted on the same field once in at least three yeas, but better once in five years);
- Potatoes require high level of soil fertility and good aeration of arable layer, but tolerate increased soil acidity rather easily;
- Winter grain crops are sown on occupied fallows and perennial grass;
- Forage and pasture crop rotations are established with the simultaneous application of increased rates of lime and fertilizers;
- Hay and pasture crop rotations are introduced on the farms where the efficiency of natural pastures and hayfields is low or their area is insufficient.

3.3. Grassland renovation and pasture management

When establishing artificial pastures, after the initial sod tillage, the grassland is renovated depending upon state of the soil – either accelerated formation with artificial seeding for one year or meadow formation by growing the so-called preliminary crops for one to three years.

On meadows with lot of sedge hummocks and infested with turfy hair grass, as well as on drained transition moors and turf fens with a high degree of peat decomposition, meadows are formed with preliminary (for one to three years) seeding of forage crops - oat, pea, vicky, annual ryegrass, and others.

All methods of grassland establishment require obligatory fertilizer application, and on acidic soils also liming.

Organic fertilizers are needed on low-fertility soils with 1 to 1,5 % humus content, on peat humus and cutover land to accelerate their mineralization. Organic fertilizers are applied in combination with mineral fertilizers, the rates of which are determined with due account for nutrients stock in soil and the composition of grass stand.

If grassland is renovated in an accelerated way, lime is applied on the top layer and incorporated together with seeding to a depth where the major part of the roots is located. If preliminary crops are grown first, lime is applied under the first crop seeded. When meadows are rototilled, lime is applied during the second pass of a rotary tiller. Lime application rates (in radical amelioration) are determined to decrease the soil reaction down to slightly acidic when establishing cereal grass stand, and close to neutral when establishing legume-cereal grass stands.

These lands should be re-plowed at least once in three to five years and then used under other crops or grass again.

Maintenance of pastures

To avoid or abate an adverse effect of grazing on the grass stands on cultivated grasslands special practice of pasture maintenance includes harrowing, top cutting of ungrazed grass, spreading of faeces, moling, weeding, helminths and microbes control, application of fertilizers, irrigation, etc.

In spring, harrowing is done to «comb» the sod and to make the topsoil loose. Mineral fertilizers are applied prior to harrowing.

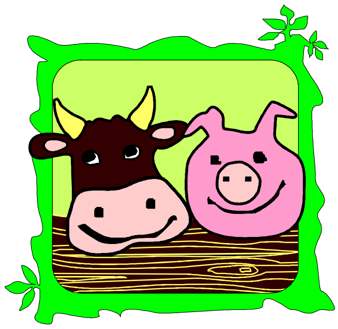
When the grass stands have a dual use, the ungrazed grass is not top-cut if after the grazing the grass is mowed for hay, grass meal or silage.

Pasture topping takes place after the second mowing in the grazing, when the highest growth of grasses is observed. If the cattle's grazing in spring is delayed, the ungrazed grass should be top cut after the first grazing.

Animals leave a significant amount of faeces on pastures. As a rule, they do not eat the grass growing around these spots. So utilization efficiency of grass on pastures drops by 15 to 18 %. Animal excrements need to be harrowed once or twice in a grazing season after the second or third grazing, and also in autumn, when the grazing period is over. When harrowing the manure on pastures, molehills are destroyed and mineral fertilizers are partly incorporated into soil. If the grass stand has a significant amount of legumes (above 30 %), especially creeping trefoil, the harrowing of manure may turn adverse, as many plants will be damaged.

The pastures located on peat-bog soil should be rolled with water filled rolls in spring as the rapid changes of temperature during the thawing result in pushing-out of plants and damaging of root systems. The rolling prevents the loss of grasses, promotes the destruction of earthen hummocks and molehills, and raises the productivity of pastures. The rolling of over-wet soil is not recommended since intense compacting decreases its air permeability. After the pasture topping, fertilizes need to be applied, and irrigated pastures need also watering.

4. ANIMAL HUSBANDRY



Animal husbandry is an ancient and essential sphere of human activity providing valuable food-stuffs (meat, milk) and raw materials (leather, wool, etc.) Intensive animal husbandry features high concentration of animals and large size of livestock enterprises. In Leningrad Oblast there are 1000 to 1200 cows on large dairy farms and up to 10 thousand bull calves on fattening farms. Private and individual farms usually have from one to several milking cows. However the basic principles of animal keeping are common for a large agricultural company and a small family farm – the animals should be healthy and productive. With this aim in view the conditions for animals have to meet their natural requirements to the utmost. At the same time the farm waste should be utilized most efficiently allowing for minimal or no environmental pollution.

4.1. Ecological requirements for livestock farms and animal husbandry technologies.

Animal breeds best adapted to local climatic, geochemical, and vegetative conditions should be included in the herd composition.

Clean (waste-free) technologies should be used; there should be a rational connection between fields and the farm to receive enough forage and fully utilize manure as a fertilizer. Available agricultural land should accept all organic wastes (manure) without breaking soil capability to utilize the organic nutrients.

It's important to study natural and climatic factors, which have an adverse effect on animals: highest and lowest temperatures, solar radiation, humidity, wind strength. It's necessary to estimate the distance from big industrial enterprises, highways, and power plants working with coal, chemical factories, cement plants and other sources of pollution. The sources of biological pollution from neighboring large animal

production companies, slaughtering and meat-processing plants, poultry farms have to be investigated (hazardous gases, dust and bacteria aerosol). Possible sanitary-protection zones and veterinary-sanitary gaps have to be established and observed.

4.2. Recommended animal density and standards for sanitary distances between animal farms and spacing of buildings.

The Russian legislation does not specifically define the standard correlation between the number of cattle and the overall agricultural area on a farm. But there exist recommendations on the optimal ratio of farm pasture area and cattle on grazing.

The size of a sanitary-protection zone of a cattle breeding company should be at least 300 m if the milking herd is of 400 cows, 500 m for 800 milking cows, and 1000 m and more for fattening farms.

Veterinary spacing of buildings for cattle breeding companies should be at least 150 m, for poultry farms at least 1000 m, and for meat-and-bone meal production plants at least 1000 m.

On an individual farm it is allowed to keep up to 200 cows, 500 fattening animals, 1000 pigs, and 20 horses. Firebreaks between the buildings should be observed.

4.3. Optimal conditions for housing the animals in cowsheds.

Optimal microclimate in animal houses provides maximal conversion of feed into products, high resistance of the organism, long-term use, and lower production costs. Microclimate parameters are state regulated, and the objective for cattle owners and farm managers is to maintain the optimal parameters all year round (Table 9).

Microclimate parameters depend on design features of livestock houses, heating and ventilation systems. In livestock houses the standard animal density, optimal size of stables, optimal temperature and ventilation rate should be provided.

In winter, ventilation rate should be minimum15 m^3/h per 100 kg of animal weight, and in spring and autumn at least 18 m^3/hour.

Estimated rate of air flow in cowsheds with the loose and tied housing system, houses for young animals and fattening animals sheds in cold weather should be under 0,5 m/sec, and in warm weather 1,0 m/sec.

In delivery room, calf-house, milking parlour, and station of artificial insemination the air rate should be maximum 0,3 m/sec in cold weather and 0,5 m/sec in warm weather.

Reduction of ammonia emissions could be reached by improving manure removal techniques; applying litter and adsorbents decreases urea decomposition rate.

Table 9. Optimal microclimate parameters for cattle houses

Type of building and age group of animals		Microclimate parameters in livestock houses							
		Tempe -rature ° C	Relative humidity %	Air flow rate, m/sec			MAC* CO_2 %	MAC* NH_3	H_2S
				Winter	Spring, autumn	Summer		mg/m^3	
Cows and young animals above 1 year of age	Tied and loose housing in cubicles	10 (8-12)	75 (40-85)	0,3-0,4	0,5	0,8-1,0	0,25	20	10
	Loose housing on deep litter	6 (5-8)	75 (40-85)	0,2-0,4	0,5	0,8-1,0	0,25	20	10
Delivery room		16 (14-18)	75 (40-75)	0,2	0,3	0,5	0,15	10	5
Nursery for calves		18 (16-20)	75 (40-75)	0,1	0,2	0,3-0,5	0,15	10	5
Houses for calves, days of age	20-60	17 (16-18)	75 (40-85)	0,1	0,2	0,3-0,5	0,15	10	5
	60-120	15 (12-18)	75 (40-85)	0,2	0,3	up to 1	0,25	15	10
Houses for young animals	Young animals of 4-12 months	12 (8-16)	75 (40-85)	0,3	0,5	1,0-1,2	0,25	20	10
	Heifers above 1 year and In-calf heifers	12 (8-16)	75 (40-85)	0,3	0,5		0,25	20	10
	Fattening bull calves	10 (8-12)	75 (40-85)	up to 1	up to 1	up to 1	0,25	20	10

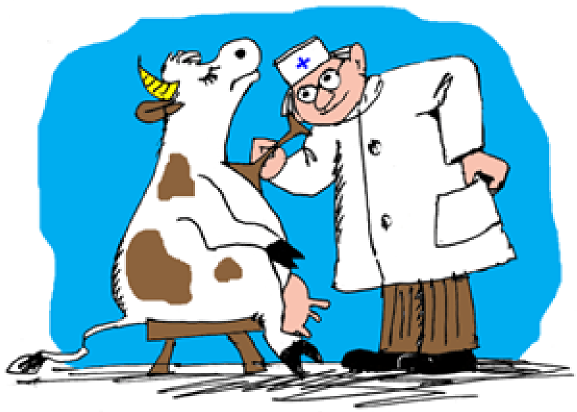
*MAC - maximum allowable concentration

The maximum allowed dust content in livestock houses is 5 mg/m^3 during the feed distribution; small traces of methane in the rooms with underground manure storage are allowed.

The noise level in livestock houses should not exceed 70 dB, and 65 dB in a nursery for calves.

4.4. Animal health control

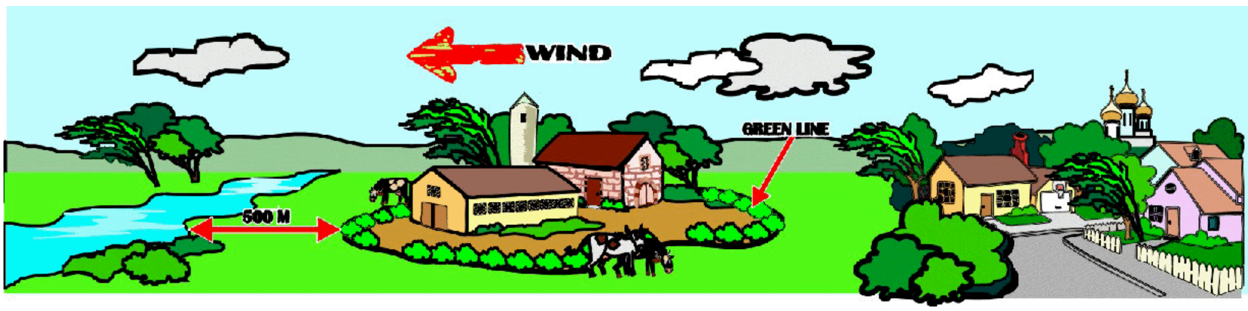
A healthy animal is an animal with normal digestion and metabolism. Such an animal has a long production period, high resistance and reproduction capacity.
Criteria of health are good outlook, smooth and shining hair, normal motion activity, comfortable resting posture, good reaction to irritants, standard physiological indices (body temperature, pulse, breath, rumination), and standard biochemical factors of blood.



Methods of disease detection are clinical examination, clinical trails, laboratory tests, analysis of housing technology and feeding efficiency, analysis of retirement of animals from the technological process, technical and economical performance, and others.

4.5. Environmental constraints in animal husbandry

It's forbidden to build livestock farms and cowsheds on the territory of former animal burial grounds, cemeteries, sewage treatment plants, manure storages, waste utilization sites of industrial and tannery plants.
The territory of animal husbandry farms should be at a distance of at least 500 m from open water systems (rivers, lakes).



When designing the farm and livestock houses and during the construction, the plants on the farm territory should be preserved to the utmost. Planting of new greenery is recommended along the borders of newly built-up farm areas.

An animal husbandry farm should be designed in such a way that manure and manure-contaminated wastewater do not pollute the environment and the ground waters; the activities for their efficient utilization should be planned to meet the requirements of NTP 17-99 standard.

It is necessary to provide a sanitary slaughterhouse, located on the farm border, for heifer growing farms with a capacity above 6000 cow-places, beef production farms with a capacity above 5000 cow-places, and for dairy farms with a capacity above 800 cows. On small-scale farms a special site should be organized with containers for carcasses.

Animal carcasses and inedible material should be disposed by:

- *Burning at high temperature*
- *In case there are no special furnaces – by burial in biothermal (concrete) bunkers*

Carcasses are prohibited for meat-and-bone and protein meal production.

Buildings for treatment of animal skin (dipper or disinfection site) should be situated in a place suited for removal of disinfection fluid.

Maximum amounts of pollutants emitted from open manure storages (per one m^3 of manure) are: ammonia - 0,0122 mg / sec; hydrogen sulphide - 0,0015 mg / sec.

A cattle-breeding farm should be situated so that prevailing winds blow in the direction opposite to housing settlement. Concentration of pollutants along the borders of a farm's sanitary protection zone in any season should not exceed the maximum allowable concentration values set for the atmosphere of residential areas.

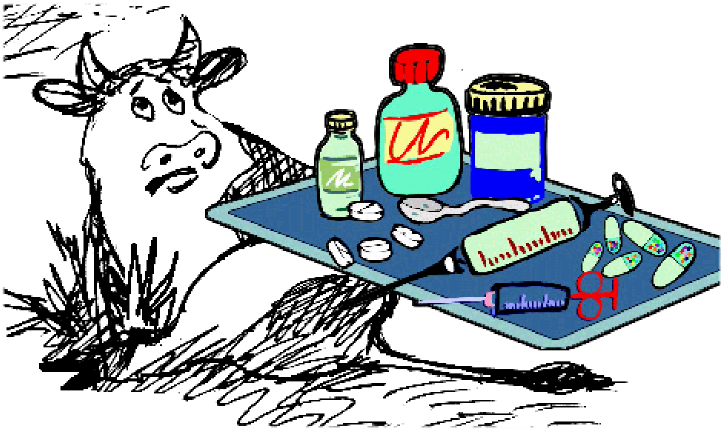
4.6. Usage of non-medical substances in animal care

The modern veterinary science uses thousands of biological preparations for medical care and diagnostics, and also hundreds of disinfectors, cleansers, and insecticides. Plenty of foreign substances enter the environment from large-scale dairy, cattle, swine and poultry farms. The animal organs accumulate heavy metals, antibiotics, and anabolic hormones, which may be exported with the milk of dairy cows. It is necessary to protect not only the ambient environment, but also the internal environment of animals.

An important trend in modern veterinary science is to avoid medicamentous therapy of animals and to apply new methods of disease prevention. They are physical exercise, herbal preparations, electrotherapy, hydrotherapy, mechanic therapy, autohemotherapy, diet therapy, massage, use of electrically activated water, and magnetic sounding of the cow fore-stomach.

Environmentally friendly disease treatment and prevention method is the one that makes use of ecological information (optical, sound, chemical signals). Eco-informational treatment and prevention of animal diseases has good prospects in veterinary.

4.7. Safe use of medicines and bio-stimulators with immunosuppressive, cumulative or allergic action



Many medical substances have side effects, which may be adverse. Some of them reduce immunobiological reactance (immunosuppressive); others are accumulated in the organism, and animal foodstuffs become hazardous for human health; yet others can cause allergic reactions. A veterinarian has to have a strict control over the application, batching, and treatment scheme with these medicines, regularly vary preparations, use combinations of preparations in smaller dozes, and do the breaks in their use for demedication.

5. CATTLE BREEDING WASTES AND SEWAGE

5.1. Cattle breeding waste

5.1.1 Types of organic wastes

Manure is an important and valuable fertilizer. Manure consists of solid and liquid excrements of animals or their mixture with litter (the remains of forage, straw, sawdust, peat, etc.). Manure may contain litter material (litter manure) and may be without litter material (non-litter manure) depending on the technology of animal housing. Manure may be solid, semi-solid or liquid depending on the dry matter content.

Solid manure contains at least 20 % of dry matter (humidity less than 80%). Usually it contains a lot of litter. It can be stored in heaps and rammed. This kind of manure features the highest nitrogen emissions and minimum loss of nitrogen through leaking. Solid manure causes less environmental pollution than semi-solid or liquid manure.

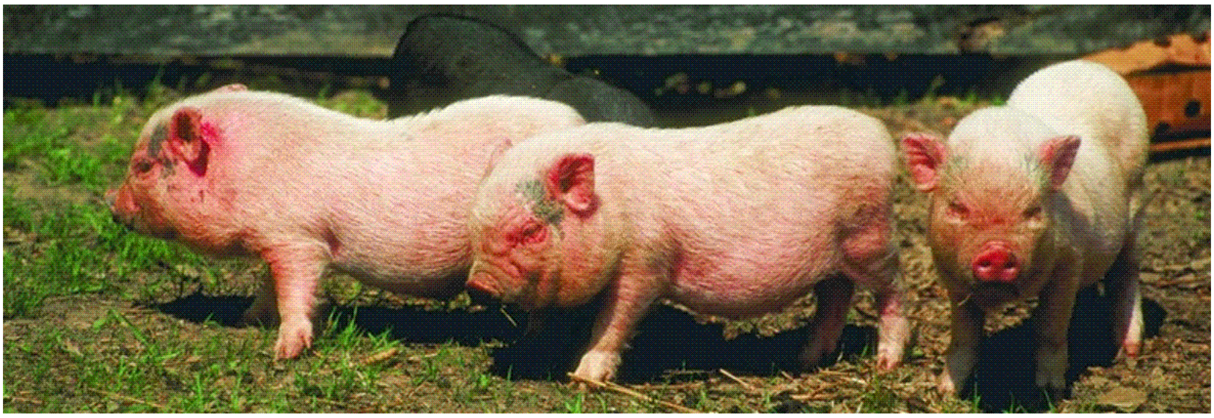
Semi-solid manure is a mixture of excrement and urine with the remains of forage and a small amount of litter. Semi-solid manure contains 12 to 20 % of dry matter. It cannot be collected in heaps or pumped. Handling, spreading, transportation and mixing in the storage are difficult. It should be composted with peat or some other substrate material in manure storages before taking out to fields.

Liquid manure (slurry) is produced when the animals are housed without litter. This is a mixture of excrement and urine. In the livestock houses, where outdated systems of manure removal by water washing are still in use, the dry matter content

and fertilizing value of manure depends on the amount of water used. Liquid manure has less than 10 % of dry matter and it can be pumped through pipelines.

Manure water (effluents) is strongly diluted litter-free manure, urine of animals together with the liquid, which appears when manure and litter are decomposed. Manure effluents contain less than 5 % of dry matter.

It is necessary to apply production technologies of solid litter manure to decrease environmental pollution by biogenic substances from organic fertilizers.



5.1.2. Cattle manure production rates

Manure amount and properties depend on the age, diets and housing of animals.

Standard output and humidity of excrements and their components for the basic groups of cattle per one animal are presented in Tables 11 and 12.

Table 11. Standard output and humidity of cattle excrements

	Cows	Calves under 6 months of age	Young animals	
			6 to 12 months of age	12 to18 months of age
Faeces, kg / head * day	**35**	**5**	**10**	**20**
Urine, kg / head * day	**20**	**2,5**	**4**	**7**
Total excrements, kg / head * day	**55**	**7,5**	**14**	**27**
Humidity, %	**88**	**86**	**86**	**86**

Table 12. Nutrients content in cattle excrements

	Nutrients content (dry matter)		
	Nitrogen N_{total}	Phosphorus (P_2O_5)	Potassium (K_2O)
Cattle manure	**3,2**	**1,8**	**5,0**

Specific features of application of various kinds of manure are presented in Table 13.

Table 13. Advantages and disadvantages of use of various kinds of manure

Advantages	Disadvantages
Liquid manure	
It is homogeneous after mixing	Litter can not be used
It can be pumped through the pipes	Emissions of hazardous gases
High nitrogen content	Pathogenic bacteria and others pathogens stay alive for a long time
It is easily metered and may be applied directly in soil	It is impossible to avoid weeds in soil
It can be spread on pastures, growing grass and even on the deserted lands	Emission of ammonia
It is easy to determine the nutrients balance	It has a lot of water and big storing capacities are required
Only one spreading and storing system is needed	
Easy to automate, less labor costs, no litter costs	
Semi-solid manure	
Litter can be used in small amounts	Large areas for storage
	It is difficult to meter and spread
	Two spreaders are required (for urine and for semi-solid manure)
	It is deficient in nutrients
	It is difficult to determine the nutrients content

	Pathogenic bacteria and others pathogens stay alive for a long time
	Small amount of weeds
	Heterogeneous composition
Solid manure	
Plenty of litter can be used	Heterogeneous composition
Small amount of pathogens and weeds when composted	Difficult to meter and spread
Soil properties are improved	Irregularity of growth across the area
It is possible to store in heaps on the field	It is difficult to determine the amount of nitrogen
Gases cause no problem, especially if it is applied in the form of compost	There should be separate storages for solid manure and effluents
	High loss of nitrogen, especially when composted
	Expensive: labour costs, transportation and processing costs, litter and compost substrate material (peat) cost

5.1.3. Manure removal from cowsheds

Manure should be removed and transported outside the cowshed in a mechanical way (by scraper, plank and screw transporters, scraper and hydraulic devices, and also bulldozers of different type) or by liquid-operated systems (pumping and self-flowing systems of continuous or periodic action).

Fluid systems of manure removal should have ventilation of canals and a hydro lock in order to stop the gases from the storage and canals from entering the cowshed.

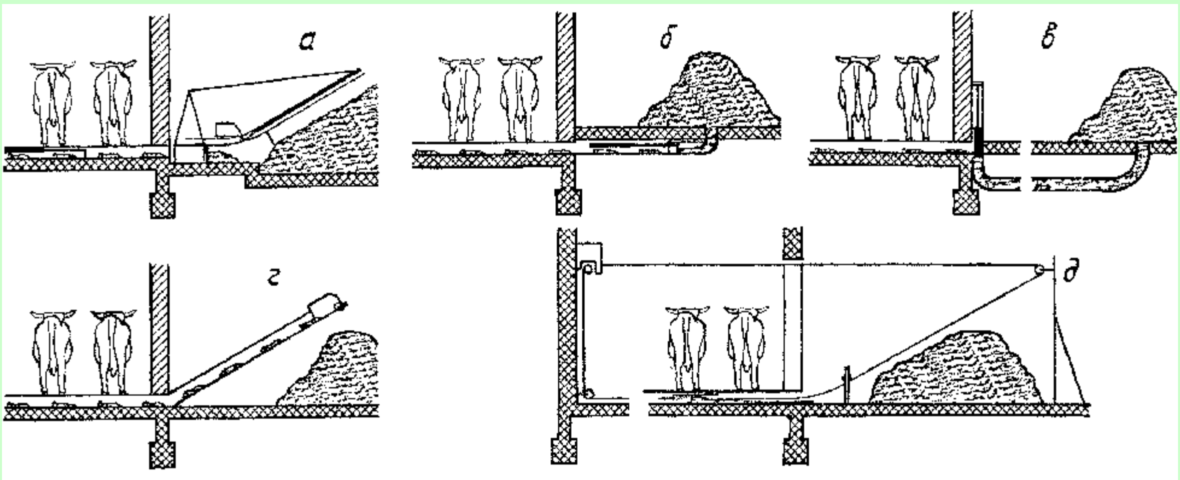


Fig. 5.1. Mechanical systems of manure removal, used abroad in tied housing of cattle;
a - bar transporter with inclined conveyor; b - bar transporter with horizontal delivery installation; c - bar transporter with vertical (mole system) delivery installation; d - scraper transporter; e – manure slides

Mechanical devices of manure removal and transportation (Fig. 5.1) have primary application on cattle farms with stable and stable-and-pasture keeping of animals on litter, in delivery rooms, in underground manure storages and on open feeding sites.

Continuous gravity manure removal system should be applied in case the moisture content of the slurry exceeds 88 % in cowsheds, where the animals are kept without litter, the forage does not have any access to manure canals, and the animals are fed with silage, fodder root crops, distillery refuse, beet chips and green mass.

Periodic self-flowing manure removal system may be installed on all livestock farms where animals are kept without litter.

To lower the amount of water mixed with manure, the washing and disinfecting in cowsheds should be done with high-pressure washing machines (OM – 22613 type, Kärcher, KEW, etc.)

5.1.4. Transportation of manure

Pumps and leak-proof vehicles can transport manure from the cowsheds to its accumulation, quarantine and treatment facilities. It is recommended to use enclosed vehicles (tanks) for transportation of liquid and semi-liquid manure.

Collection pits (receiver tanks) of manure should be located outside the livestock houses and hold not less than half of the daily amount of manure. A note from the Finnish experts of the team: "If the manure is pumped or flows automatically to the storage, there is not need for special reception tanks, but the Russian legislation makes them obligatory. Another regulation states that the storages cannot be closer than 60 m from the cowshed. These regulations harm in many cases the rational planning of manure handling without any rational reason for them, especially if the cowsheds have a self-flowing slurry manure system."

The receiver tank of the pump station should be equipped with a system for removal of large inclusions exceeding 50 mm, and devices for mixing the manure effluents to prevent sedimentation.

To pump the liquid unseparated manure pumps with crushing devices are applied. Horizontal pumps must be mounted lower than the bottom of the storage. The diameter of the suction main should not be less than 200 mm, and that of the pressure line not less than 150 mm.

5.1.5. Manure storage

Storing time of ecologically safe kinds of manure and fertilizers on their basis is defined by the period of subzero weather and varies from four to ten months. Recommendation for Leningrad Oblast 8 months manure storage when the animals go to pasture in summer time, and 12 months manure storage if the animals are kept inside the whole year.

Liquid manure is stored in the by-farm or field storing capacities of unit type. To combine the processes of storing and quarantine of manure the storage must have no less than three units (cubicles) according to Russian recommendations.

Litter-free manure and dung are stored in trench or round sub-surfaced or on-ground storages (Fig. 5.2.). Open sub-surface storages should have a protective fence, minimum 1500 mm above the ground level, and a concrete wall at the edge, minimum 300 mm above the ground level. The bottoms, slopes and walls of storages should be waterproof. Equipment for mixture and unloading of manure can be stationary or transferable.

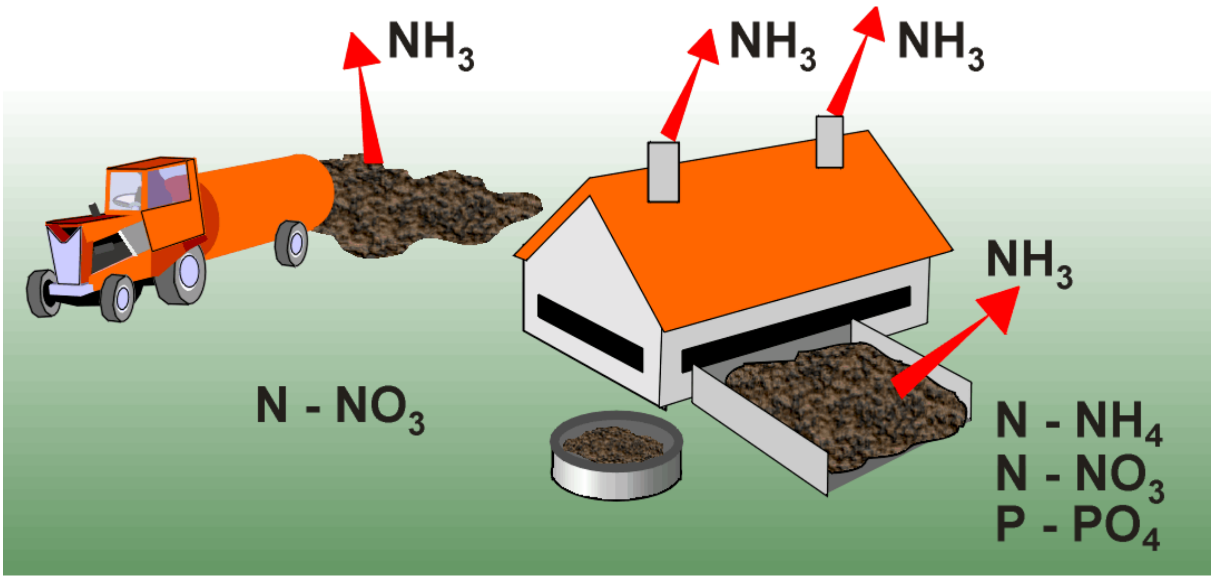


Fig. 5.2. Methods for storage and soil application of manure and their disadvantages.

Waterproof platforms bordered with ditches or storages of up to 2 m deep are used to store litter manure and solid fraction of manure after their separation. Catch pits (slurry tanks) are provided to accumulate and remove the liquid part (effluents) from the storages and platforms. The storage bottom must be inclined towards the catch pit. Covered storages and platforms are recommended for storing all kinds of manure and fertilizers on their basis (Fig. 5.3).

Litter manure and compost are allowed to be stored on the field sites where a waterproof layer is formed from clay or watertight membrane (Fig. 5.4).

The yield of cattle manure in the pasture period is 50 % of average daily yield; in extensive housing the yield of cattle manure is 85 % of the average daily yield.

To provide gravity separation of the liquid fraction, filtering walls, grids and other devices are allowed to be installed in the manure storages in case the farm receives problematic semi-liquid manure from the cow-sheds.

Litter manure is unloaded from the storage by mobile loaders; litter-free manure is unloaded by self-loading trailer tanks, which are equipped with spreaders of МЖТ type, or pumps of НЖН-200 or НЦИ-Ф-00 type, etc.

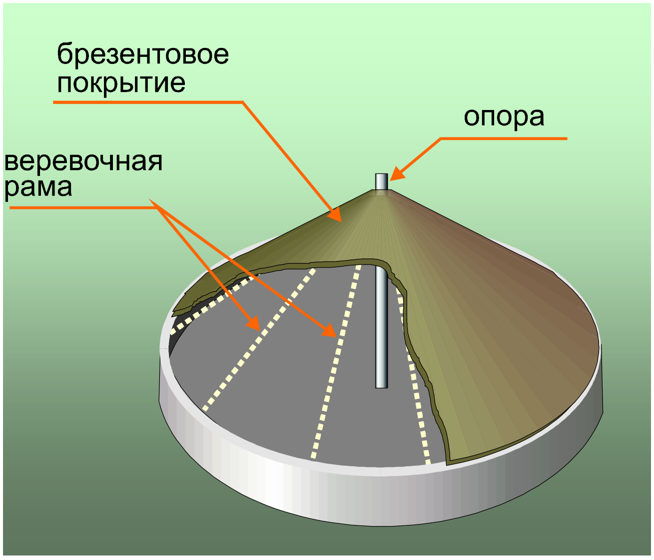


Fig. 5.3. Light cover of manure storages

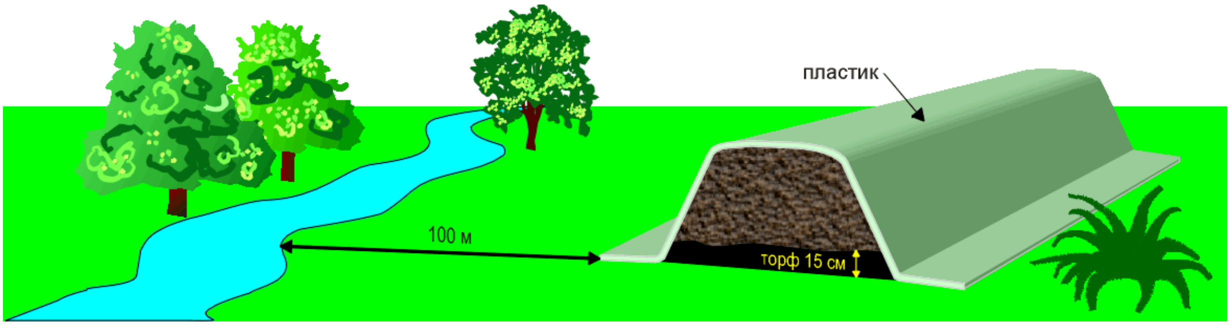


Fig. 5.4. Manure stack

5.2. Treatment of production sewage and land run-offs from farm territory

The design of constructions for manure utilization should include facilities for collection and appropriate treatment of production wastewater and land run-off from the farm territory, otherwise the wastewater will inevitably pollute the soil and open water systems. Clean wastewater should be recirculated in the farm water supply system or discharged into a domestic sewage system or a storm collector. Domestic wastewater from individual sanitary facilities in livestock houses may be discharged into closed manure canals and storages.

Methods of cleaning and the required purification rate of production wastewater are determined depending on local conditions with due account for their maximum possible application in irrigation of fields after their full biological cleaning. Production sewage from slaughterhouses is to be discharged into the sewage system only after the fat, blood, feathers and other wastes are removed.

Biological ponds are recommended for biological treatment of wastewater from the farms. Aeration tanks, operating in prolonged aeration mode, or high-rate biological filters (aero filters) are recommended for biological treatment of production wastewater after pre-sedimentation. The Sanitary Regulations and Rules «СНиП 2.04.03-85» govern proportioning of structures for biological cleaning of production wastewater. Artificial and natural methods are applied for biological cleaning of the liquid fraction of manure effluents depending on the required purification rate.

In treated manure effluent the BOD should be from 5 up to 10 to 15 mg/L, and the dissolved oxygen content up to 6 mg/L.

Storm run-offs from the farms are directed via an open sewage system to local storages (sewage tanks or ponds); after being treated they are used for irrigation of agricultural lands.

Run-offs from the building roofs and the territories, which are not polluted with animal waste, forage remains, and oil products, are discharged on terrain, on fields or in reservoirs. Storm run-offs from exercise areas and other territories polluted with manure can be used on agricultural lands after the quarantine according to the regulations ВНТП 01-98 “Irrigating systems, which use the sewage and livestock wastewater”.

5.3. Preparation of manure for use as an organic fertilizer

It is recommended to process litter manure with up to 78 % moisture content into an organic fertilizer by fermentation and biothermal disinfection. Manure with up to 88 % moisture content is first mixed with an organic filler so that the dry matter content is minimum 25%. Peat is the most preferable substrate due to its ammonium absorbing capacity. Straw, bark and saw dust can also be used.

Slurry, with humidity above 88%, can be stored, transported and applied to fields without composting. This manure handling system is the most commonly used in the EU countries due to its cost-efficiency. A lot of information is available on the technology, machinery and construction drawings.

Semi-solid manure, with water content of 80 to 88% is difficult to handle, it cannot be pumped and it cannot be transferred with loaders. In storages it separates into fractions, the solid fraction on the top with the liquid one under it. After that, the mixing is difficult or impossible. Therefore a separate urine collection system should be used in the cowsheds, and/or enough litter should be introduced to obtain the solid manure; or it is recommended to collect manure and urine mixed together, with no litter used, possibly adding sewage or wash waters, in order to get slurry that can be pumped or taken out by a self-flowing system. If anyhow the production technology of existing premises is such that semi-solid manure cannot be avoided, it is necessary to apply mechanical separation into solid and liquid fractions for future separate use. The solid fraction with the humidity up to 70 % is first disinfected in a biothermal way in clamps or in special bioreactors, and then applied as an organic fertilizer. The liquid fraction is stored for some time in a storage tank/bunker and then spread on the fields as a fertilizer.

5.3.1. Manure separation into fractions

In the case, the manure from the existing cowshed is semi-solid - and it is not possible to renovate the system for separate urine collection or apply litter enough to get the solid manure or change to slurry system, without litter application - manure in the storage should be separated into fractions, which are handled separately. Hereunder is a description of the technologies, which can be applied for this purpose. Note that they are expensive and labour demanding, especially for large farms.

Filtering machines are applied to mechanically separate coarse particles from the liquid manure (arc sieve, filtering centrifuges, shaking sieves, filter presses), which provide 82 to 85 % moisture content of the solid fraction.

High-speed settling centrifuges are used for more effective separation of liquid manure to produce the solid fraction with less than 70 % moisture content. High speed settling centrifuges with long rotors, or vacuum filters with preliminary conditioning of sediments by flocculants, which provide up to 95 % isolation of suspended particles with 80 to 82 % moisture content of the solid fraction, are applied to separate sediments and sludge from settling tanks.

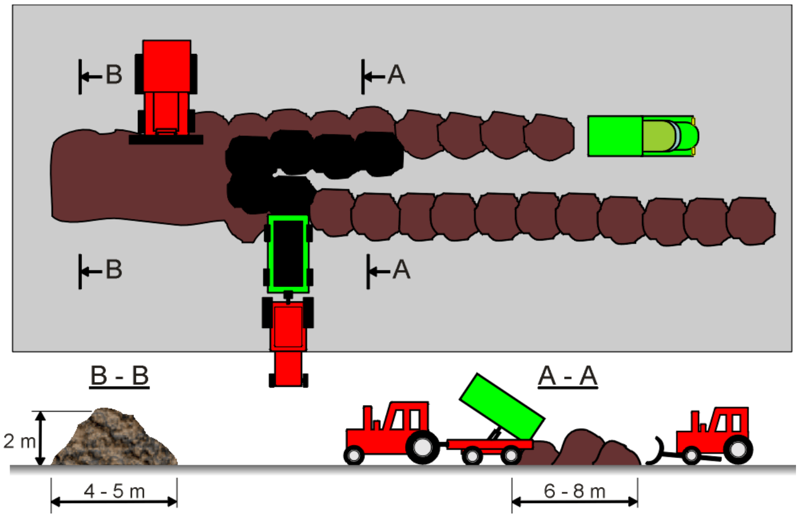
5.3.2. Manure composting

Composting is recommended for all kinds of manure with up to 92 % moisture content mixed with organic substances (fillers). The mixture is composted on by-farm open sites or in stationary mechanized shops by mobile and stationary devices. In warm seasons the compost may be prepared on specially designed field grounds

situated close to fertilized agricultural lands. Technological process of manure composting can be performed in a passive or active way.

The passive (traditional) way is the composting under natural conditions in clamps on by-farm or field grounds. It includes:

- thorough mixing of components,
- formation of clamps,
- seasoning (aging) of the mixture in clamps,
- aeration and storage of the ready compost.



Fig, 5.5. Diagram of semi – solid poultry manure composting.

Duration of manure composting is from one to three months at an air temperature above 10°C. If bark or sawdust is applied, the process becomes 1.5 to 3 times longer. If the temperature of the mass in the clamp drops to 25 - 30ºC, the mixture should be aerated by mixing the layers. In winter the mixture should be stacked in one compact pile with the height of up to 2 to 2,5 m. Under steady positive temperatures the mixture is aerated and stacked in clamps of standard size.

Active (accelerated) manure composting is performed in a continuous mode in special heat-insulated bio - fermenters of various forms and designs. The technological process of accelerated composting involves continuous or periodic air delivery into the bio - fermenter. The composting of the mix lasts for five to seven days.

5.4. Anaerobic treatment of manure

Anaerobic treatment of litter-free manure, sediments from settling tanks and other high-carbon organic materials (straw, grass, silage, etc.), and their mixes is done to produce biogas for power plants.

The requirements of anaerobic fermentation are as follows:

- the initial mass should be freshly mixed, with maximal content of organic matter, homogeneous in composition, uniform in terms of solid and suspended particles concentration, and have the maximal temperature;
- the initial mass should not contain inclusions above 30 mm and solid particles, the density of which essentially exceeds that of a liquid (concrete, clay, sand, and other extraneous inclusions);
- the initial mass should have optimum parameters: 90 to 92 % moisture content, pH - 6,9 to 8 %, fat acids content – 600 to 1500 mg/L, alkalinity - 1500 to 3000 mg/L of CaCO, C : N ratio = 10 to 16.
- the initial mass should not contain substances which inhibit methane-producing micro-organisms above permissible concentrations (ammonia nitrogen, heavy, alkaline, alkaline-earth metals, sulfides, oxygen, etc.).

Anaerobic fermentation of organic materials may take place in the following modes:

- mesophile mode with a temperature range of 33 to 38 degrees;
- thermophilic mode with a temperature range of 53 to 55 degrees.

Anaerobic fermentation of manure lasts from 5 to 20 days depending upon the kind of material, charge doze, operation mode, operation rate, and maximum level of organic matter decomposition.

When fermenting cattle manure the productive capacity in terms of biogas (calculated per 1 kg of absolutely dry organic matter) of a methane tank with the charge doze of 10 % and maximum level of organic matter decomposition of up to 40 % is 300 L. The final product (biogas) has the following parameters: calorific efficiency above 23 MJ, CH_4 content – 65 to 70 %, CO_2 - 29 to 34 %, H_2S - 0,2 to 0,3 %.

5.5. Vermicomposting

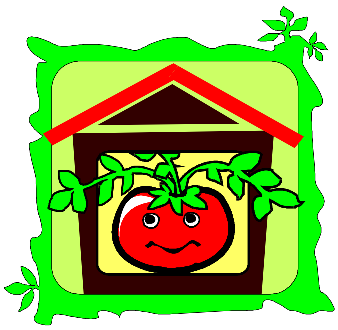
Vermicomposting of manure is used to produce high-quality fertilizer with high content of humus matter. Preparation of substrate is the basic operation in vermicomposting. It includes conditioning of organic wastes to 75 to 78 % moisture content with subsequent fermentation to transform ammonia nitrogen into nitrate forms. The initial mixture (a substrate for vermicomposting) should have the following parameters: 70 to 75 % moisture content, pH – 6,5 to 7,5, C: N ratio = 20 : 1, mineral matter content – up to 10 %, and crude protein content – not exceeding 25 %.

Such substrate may be vermicomposted all year round in closed heated rooms on racks and on floor beds. The width of the racks and floor beds should be up to 1,2 m**,** the length is not strictly specified, and the height of the substrate layer up to 0,3 m.

In the warm season, when the ambient air temperature is above 10 °C, vermicomposting may be organized on open grounds in beds.

The output of vermicomposting facilities is, for the indoor and outdoor production, correspondingly: in terms of initial substrate of 1,5 and 0,7 t/m^2, ready biohumus - 0,7 and 0,33 t/m^2, biomass of vermiculture - 22 and 10.5 kg/m^2 per year.

Biohumus (the final product) should have the following parameters: 70 % moisture content, pH - 7,5, total nitrogen - 1,0 to 1,5 %, P_2O_5 - 1,0 to 1,3 %, humus content - up to 12 % from the weight of absolutely dry matter.



6. INTEGRATED AGRICULTURAL CROPS PROTECTION

6.1. General methods of plant protection

The system of plant protection is a reasonable combination of preventive (quarantine, agro-technical) and destructive (mechanical, biological and chemical) actions.

Quarantine method. Quarantine actions are aimed to prevent interregional spread of pests and diseases.

Agro-technical method. Agro-technical actions are focused on the creation of conditions favorable for plant development and unfavorable for pests and disease agents. Thus, observing recommended patterns and the timely seeding and planting of crops, adequate crop rotation, fertilization, regular watering, soil tillage, weed

control, and utilization of plant residue, contribute to the better development of cultivated plants, and to raise their pest and disease resistance.

Biological method. The guideline of this method is to protect the plants against harmful microorganisms with the use of natural enemies of the latter, i.e. entomophages, parasites and disease activators.

Chemical method. It involves the use of chemical compounds or their mixes for pest, plant diseases, and weed control regardless of the production technique of the chemical compounds applied or their action mode. Chemical plant protection includes application of insecticides, akaricides, bactericides, fungicides, chemical sexual sterilizers, antibiotics, hormonal preparations, pheromones, sexual attractants and other chemical compounds.

6.2. Risks of pesticides use

Pesticides are needed for pest, weed, and plant and animal disease control, for plant growth control, pre-harvest removal of leaves and curing of plants.

The effect of poisons on biocenoses, however, is integrated and diverse. Many insecticides have a negative impact on pollinating insects (bees, bumble bees, etc.) that results in abnormal pollination and lower yields.

Also there are facts available of the negative impact of pesticides on birds. Application of some organochlorine insecticides and biocides in poison baits poses a particular threat. In many cases birds have died immediately after the application of these chemicals on fields or plants.

Application of pesticides may lead to the loss of useful mammals, though, in general, they are more tolerant to pesticide action than birds.

Large-scale application of pesticides may result in contamination of water systems. This may occur when pesticides are used for pest control of agricultural plants and forest plantings on big areas. When pesticides get into the water bodies, aquatic organisms, which serve as feed for fish, perish. Regularly applied pesticides kill predacious and parasitic insects, and beaked mites.
Improper use of pesticides disturbs soil fauna and flora, physical and chemical properties of soil, and finally deteriorates soil fertility.

Pesticides cause intoxication or other negative consequences (bareness, cumulation, allergy, mutation, etc) for warm-blooded organisms at direct contact or through food chains. As a rule, pesticides also contaminate the products received in such cases from farm animals.

6.3 Use of disease and pests development prognoses

Annually from 15 to 40 % of yields are lost due to pests, diseases and weeds. To avoid these losses, it is necessary to accurately determine the number and identify the vulnerable development stages of harmful objects at which the treatments will be economically sound, in order to choose the most effective preparation in each specific case. Only after that recommendations for undertaking the protective actions

should be made. There is a phytosanitarian service in Leningrad Oblast established to carry out such activities.

The objectives of this service are regular monitoring of occurrence and development of pests, diseases of farm crops and weeds; duly warning land users about the time for preventive and destructive plant protection actions; development of long-term and short-term forecasts of the outbreak time and number of pests and diseases; the control over observance of application terms; analysis of biological efficiency of plant protection actions; diagnostics of pests, diseases and weeds; advisory service for agronomists of big farms and private farmers on crop protection issues.

6.4. Reduced pesticide application due to alternative plant protection methods

- Agrotechnical method;
- Biological method;
- Analysis of the «pest- entomophage» ratio and canceling of treatments;
- Choice of resistant varieties and hybrids, use of disease-free and clean material only. Essential advantage of resistant varieties use is the high efficiency of all plant protection actions, and an opportunity to apply less toxic preparations in smaller quantities;
- Local applications in the places of pest accumulation.

6.5. Pesticide application techniques

To control hazardous organisms, pesticides are applied in various ways: spraying, dusting, fumigation, or aeration, with aerosols, poison baits, disinfection, etc.

Spraying

Spraying is the application of a pesticide in drops to the needed surface (leaves of plants, bodies of insects) using special devices, called sprayers. Spraying is a general method of applying pesticides as it is used to protect the plants against various harmful organisms (rodents, insects, ticks, slugs, fungi, bacteria, and weeds). The advantage of this method is a comparatively small consumption of active substances; a uniform covering of sprayed surfaces, good adhesion and ability of pesticide to stick. The disadvantages of this method are some difficulties to prepare solutions and, in some cases, big water consumption.

The results of spraying to a considerable extent depend on adhesion and on the ability of a pesticide to stick on the treated surface under wind, rain and other factors.

Spreading of granulated pesticides

Granulated preparations are applied against some harmful insects damaging elevated bodies of plants and terricolous insects, damaging seeds and shoots of plants. The advantage of the application of granulated insecticides is a significantly

lower loss of preparation due to wind drift and airflows. When treating the crops with granulated pesticides the burning action of the preparation on plants, the negative impact on useful insects (entomophages, bees), and human health hazards are also much lower.

Fumigation and aerosols

The main point of fumigation is the introduction of the pesticide into the air in vaporous or gaseous state. After absorbing the poisonous substance by breathing, a harmful organism gets poisoned and perishes. Fumigation is one of the most widespread ways of pesticide application. It is used in rodents, insects, ticks, slugs, and nematodes control, as well as against plant diseases of fungal and bacterial origin. Aerosol method is application of pesticides in the form of fog or smoke.

Poisoned baits

These consist of the application of pesticides in/on attracting feed or other material: grain, cereals, flour, chaff, etc. Damp, moist and dry poisoned baits are used. Damp baits are made by impregnating bait material with the pesticide solution or suspension. The moist poisoned baits are made letting the damp baits slightly dry. Dry baits are prepared by mixing the components. Adhesive substances - mineral oil, flour paste, etc. - can be added to the baits. They are mainly used against rodents and harmful insects.

Seeds treatment

The surface of seeds and planting material is covered with dry and liquid pesticides to protect them and the plant shoots against damage by harmful rodents and insects, and to kill the plant disease activators of fungal or bacterial origin. The treatment can be with humidifying, moist, wet or dry preparations. In some cases thermal treatment is used.

6.6. Labour safety and protection of environment

Legal entities and physical persons, when using chemical substances in farming practice, are obliged to take measures to prevent the negative impact of chemicals, to cure the adverse effects, to ensure environmental quality, sustainable performance of ecological systems, and natural landscapes preservation. Application of pesticides which are not included in the State Catalogue of pesticides and agricultural chemicals, registered and approved for application on the territory of the Russian Federation, is prohibited.

Storage of pesticides

Storage of unpacked pesticides is prohibited. Pesticides have to be kept away from mineral fertilizers, chemical forage preservatives, fodder additives, paints, varnish and other goods and materials.

The place where outdated pesticides are stored has to be marked with the warning sign “Discarded pesticides”.

Pesticides are placed in the storehouse with due account for their toxicity, the form of preparation, fire and explosion risks, and chemical compatibility (neutrality).

Pesticides have to be stored in covered storehouses, that have sanitarian certificates and are equipped with fire-extinguishing means. The storage also has to protect pesticides against direct sunlight, moisture, dirt, and mechanical damage.

In case the packages get damaged, the pesticides have to be re-packed immediately in special places equipped with local exhaust ventilation. The pesticides are given to the staff in the amount needed for daily use.

Transportation

Transportation of pesticides is allowed only in specially equipped vehicles or in containers excluding the adverse effect on human health and ambient natural environment.

Containers for transportation should be made of waterproof and strong materials resistant to impacts during falling, filling and draining. Joint transportation of various pesticides and chemicals, which chemical reaction could cause spontaneous inflammation if the package is broken, is prohibited. Transportation of pesticides to the place of spraying has to be carried out by special assistants for filling up.

Application of pesticides

Only special equipment is allowed for application of pesticides.

The moving direction of machines used for the purpose is to be against the wind, and persons, working with backpack sprayers must move away from the reach of sprayer drops. All working solutions have to be prepared in tanks on special filling sites with a solid surface. During the filling up of the sprayer the staff should stay on the windward side of the site. The amount of substances on the filling site should be of daily need or less.

Application of pesticides by aviation is forbidden on the lands located closer than two km to residential areas, natural reserves, parks, fish breeding ponds, and sources of freshwater supply.

Requirements to application of pesticides

- To use pesticides only on demand.
- To consider alternative decisions.
- To promote modes and technologies of reducing or excluding the use of pesticides.
- To avoid excessive expenditure of pesticides with the help of accurate calculation of the needed quantity and to prepare the minimal required quantity for dispersion.
- To apply pesticides on sown areas and on natural pastures only in special cases with the permission of the authorities.
- It is forbidden to spray pesticides if the wind speed exceeds 5 m/sec, the air temperature exceeds 25ºC, or if there is a risk of leaching.
- To observe the protective zones when spraying to avoid pesticides leaking to natural water systems. Not to apply pesticides close to water sources and water bodies.
- The protective area for surface spraying must be at least 300 meters wide, for spraying by aviation – 1000 meters wide.

Recycling and destruction of pesticides

The pesticides are destroyed in lots up to 10 kg in the following cases:
-pesticides have become invalid as a result of their long or wrong storage or pollution by foreign material, and cannot be used for treatment;
-the remaining unused pesticides are in the form of working solutions, which cannot be applied as directed.

7. LABOR SAFETY IN CATTLE BREEDING AND FEED PRODUCTION

The specific feature of technological processes in cattle breeding is that animals, as well as people, are active participants, and often they may be injured. Current feed production and farm animals feeding feature a wide variety of feeds, which differ in biochemical composition, especially those used in feeding high-yield animals.

Nowadays in cattle breeding practice, significant amount of manual work is still used. This may be explained by the specific features of dairy cows keeping – animal care, milking, fodder preparation and distribution, obstetrics in calving, keeping the animals in maternity wards, etc.

In the package of safety measures in cattle breeding the following are of higher priority:

- Choice of safe technological processes, techniques and work regimes;
- Choice of houses and equipment which are most adapted to animal needs;
- Optimal location of equipment, cow places and technological sites for the safe work of the personnel;
- Regulatory control over mechanical, automated and manual operations;
- Timely and systematic personnel training on safe methods and techniques, and safety measures;
- Use of individual and collective protective devices when handling chemicals, fodder mixing and storing, disinfection of rooms, etc.

When working with animals much attention must be paid to zoo-hygiene, otherwise diseases may spread. Proper fixation of animals is very important during preventive, treatment or diagnostic actions. Violation of safety requirements may cause accidents with people and animals. Stud bulls are most dangerous from the standpoint of injury in cattle breeding. Only personnel who are trained on safety measures should take care of animals.

When mixing, storing and distributing the feeds, special attention must be paid to chemical and biological fodder preserving agents. In most cases, the preserving agents are concentrated organic acids with strong smell, which have an adverse effect on human and animal skin and on metal parts of machines and equipment. It is also important to accurately apply the recommended quantities when working with preserving agents and to use protective means (glasses, gloves, special clothes, masks, etc.).

To prevent injuries in cattle breeding and feed production the following organizational, technical and engineering measures are to be taken in the first place:

- Choice of optimal production technologies and methods best suited for a particular animal herd;
- Usage of machinery and equipment, which are in good working conditions;
- Improvement of technologies to increase the efficiency and to decrease the number of manual operations to avoid potential injuries;
- To appoint only trained staff to perform key technological operations.

ANNEX

A. List of Regulatory Documents and Normative-Reference Materials

1. Federal Law № 4979-1 dated 14.05.1993. «On Veterinary»
2. Federal Law № 109 dated 19.07.1997. «On Safe handling of pesticides and agrochemicals»
3. Federal Law № 89 dated 24.06.1998. «On Production and Consumption Refuse»
4. Federal Law № 101 dated 16.07.1998. «On State Regulation of Fertility of Lands of Agricultural Designation»
5. Federal Law № 52 dated 30.03.1999. «On Sanitary and Epidemiologic Welfare»
6. The Law of Leningrad Oblast № 41-оз dated 12.07.1999. «On Soil Fertility of Land of Agricultural Designation in Leningrad Oblast» (with Amendments of September, 27, 2005)
7. Federal Environmental Protection Law № 7 dated 10.01.2002
8. Federal Law № 167 dated 16.11.1995 «Water Code of the Russian Federation»
9. «Statute on State Sanitary and Epidemiological Service of the Russian Federation», The Russian Federation Government Decree № 554 dated 24.07.2000
10. «Regulations on State Sanitary and Epidemiological Standards», The Russian Federation Government Decree № 554 dated 24.07.2000
11. Sanitary Regulations and Norms (SanPiN) 1.2 1077-01. «Hygienic Requirements to Storage, Application and Transportation of Pesticides»
12. Sanitary Regulations and Norms (SanPiN) 2.1.5.980-00. «Hygienic Requirements to Surface Water Systems Protection»
13. Sanitary Regulations and Norms (SanPiN) 2.1.4.1110-02. «Sanitary Protection Zones around Freshwater Supply Sources and Pipelines»
14. Sanitary Regulations and Norms (SanPiN) 2.2.1/2.1.1.1200-03. Sanitary and Epidemiological Rules and Norms «Sanitary Protection Zones and Sanitary Classification of Enterprises, Buildings and Other Objects»
15. State Standard ГОСТ 12.3.041-86 «Application of Plant Protection Pesticides»
16. Recommendations «Scientifically substantiated manure application in Leningrad Oblast» Publisher: Russian Academy of Agricultural Sciences, Leningrad, 1987
17. Methodological recommendations «Scientifically substantiated technology of fertilizers and lime use». Publisher: North-West Research Institute of Agricultural Engineering and Electrification – SZNIIMESH, St. Petersburg, 1997
18. Recommendations «Drawing a fertilizer application program». Agriculture Ministry of the RF, «Rosinformagrotech» Publishers, Moscow, 2000
19. Agronomist Guidebook for Non-Blacksoil Zone of the Russian Federation. Moscow, «Agropromizdat» Publishers, 1997
20. Mineyev V.G. et al. «Biological Farming and Mineral Fertilizers». Moscow, «Kolos» Publishers, 1993
21. State Standard ГОСТ 26074-84. « Liquid Manure. Veterinary and s Sanitary Requirements to Its Treatment, Transportation and Application»

22. Sanitary Rules 1.2.11720-02 «Hygienic Requirements to Safety of Agrochemicals»
23. Recommendations of Helsinki Commission, Agriculture Ministry of RF, «Ecology and Business» Publishers, St-Petersburg, 2002

B. Regulations for activity in water protection zones

The Water Code of the Russian Federation (Federal Law No 167) regulates the legal relations concerning the use and protection of water resources.

Designing of water protection zones and riparian protective strips, establishing their limits, and other environmental actions in this concern should comply with «Regulations on Water Protection Zones of Water Bodies and Their Riparian Protective Strips», the Russian Federation Government Decree of November 23, 1996, № 1404.

On the territory of Leningrad Oblast the size of water protection zones is regulated by the Decree of the Governor of Leningrad Oblast of January 26, 1999, № 19-пг «On Establishment of Minimal Size of Protection Zones of Water Bodies in Leningrad Oblast and Their Riparian Protective Strips».

A water protection zone is a specially allocated territory close to rivers, lakes, and other surface water bodies, where a set of actions is introduced – organizational, meliorative, agrotechnical, forest-meliorative, sanitary-and-hygienic, and others, aimed to protect the water bodies against pollution, siltage and depletion, and also to preserve the habitat for flora and fauna representatives.

In water protection zones *special regulations* are established for economic and other activities, which are aimed to improve the hydrological, hydrochemical, hydrobiological, sanitary and ecological state of water bodies.

Riparian protective strips are established within the limits of a water protection zone along the banks of perennial water streams and reservoirs, where additional restrictions of nature management are introduced.

B.1. Establishing the size of water protection zones

The width of water protection zones and riparian protective strips is established on the basis of:
For rivers, cut-off lakes and lakes – the mean annual water level (rim) in summer;
For water reservoirs – the rim at a normal headwater level;
For seas – maximum tidal level;
For bogs – their borders (zero depth of peat bed).

The minimal width of water protection zones is established for the rivers, lakes, water reservoirs, and bogs as presented in Table 14 and Table 15.

Table 14. The minimal width of water protection zones

River length from the source, km	Width of the water protection zone, m
Up to 10	50
From 10 up to 50	100
From 50 up to 100	200
From 100 up to 200	300
From 200 up to 500	400
From 500 and longer	500

For the *sources of rivers and springs* the water protection zone is established with a radius of at least 50 m.

Table 15. The minimal width of water protection zones for lakes, water reservoirs and bogs

Water area, км^2	Width of the water protection zone, m
Up to 2	300
from 2 and bigger	500

The limits of water protection zones of *canals* are the same as right-of-way borders.

Sanitary Rules and Norms (SanPiN) regulate the size of sanitary protection zones around freshwater supply sources.

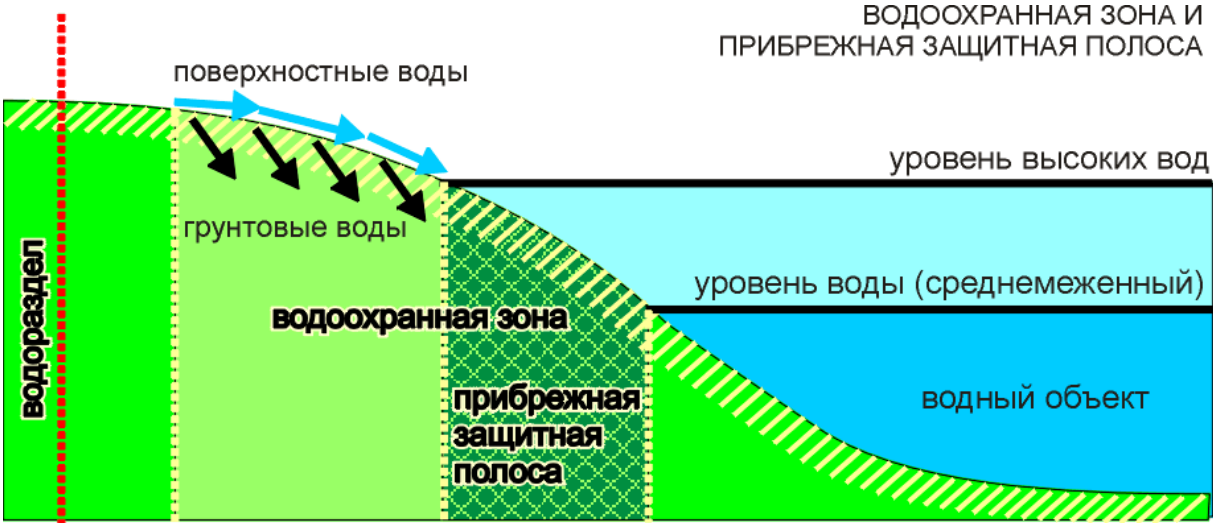
The minimal width of riparian protective strips for rivers, lakes, water reservoirs and other water bodies is established as presented in Table 16.

Table 16. The minimal width of protective strips for the rivers, lakes, water basins and other water objects

Kinds of lands adjacent to a water object	Width of a riparian protective belt, m with the degree of slope of adjacent territory, degree		
	reverse and level slope direction	Up to 3°	above 3°
Arable land Meadows and hayfields Forests and bushes	15-30 15-25 35	35-55 25-35 35-50	55-100 35-50 55-100

The width of riparian protective strips for the parts of water bodies, that are especially important for fish farming (places of spawning, wintering fish basins, feeding areas, and others), is established not less than 100 m.

In settlements, where there is a storm water drainage system in place and a quay, it is allowed to establish the border of the riparian protective strip along the quay parapet.



B.2. Features of water protection zone use

Within the limits of water protection zones a special routine for economic and other activities is established, whereof special water protection signs (marks) inform the population.

Within the limits of water protection zones it is prohibited:

- To work with chemicals using aircrafts;
- To apply plant protection products, and agents of pest, disease and weed control;
- To apply liquid manure and manure-bearing wastewater for soil fertilizing;
- To arrange storehouses for pesticides, mineral fertilizers and petroleum, oil and lubricants; sites for refilling pesticide sprayers; livestock complexes and farms; storing and burial places for industrial, household and agricultural waste; cemeteries and animal burial grounds; sewage storages;
- To store manure and garbage;
- To fuel, wash and repair cars and other vehicles and mechanisms;
- To build summer cottages and arrange gardening plots if the width of a water protection zone is less than 100 meters and the sloping degree of adjacent territory exceeds three degrees;
- To arrange the parking lots for cars and vehicles, including the territories of summer cottages and gardening plots;
- To perform final felling operations;
- To construct and reconstruct buildings, communications and other objects, and also to perform mining operations, digging and other works without the approval of the basin and other territorial authorities responsible for water resources use and protection of the Ministry of Natural Resources of the Russian Federation.

On the territory of water protection zones the intermediate cut and other silvicultural operations aimed to protect the water bodies are authorized.

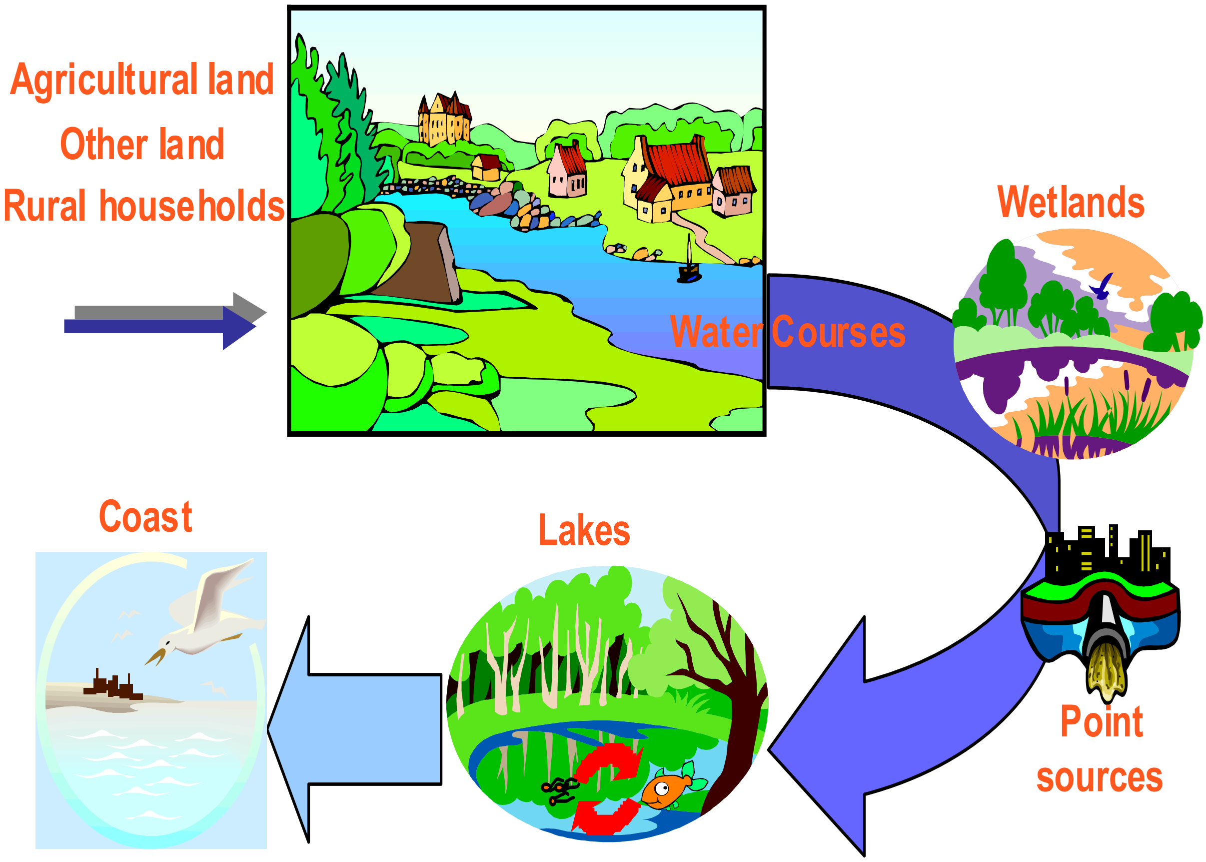


Diagram of nutrients terrestrial load (by Lotta Andersson)

Within the limits of riparian protective strips in addition to the restrictions for water protection zones it is prohibited:

- To plow the lands;
- To apply fertilizers;
- To arrange dumps of eroded soil;
- To graze animals and to arrange summer camps for cattle (except for the use of traditional watering places) and cattle baths;
- To arrange seasonal tent camps;
- To build summer cottages and to arrange gardening plots as well as to allocate the sites for individual construction;
- To organize traffic of cars and tractors, except for special purpose vehicles.

The sites within the limits of riparian protective strips are allocated in case the license for water use is available and the sites are used to place the objects of:

- Water supply;
- Recreation;
- Fish and hunting facilities;

and also the facilities of:

- water intake;
- port;
- hydraulic engineering.

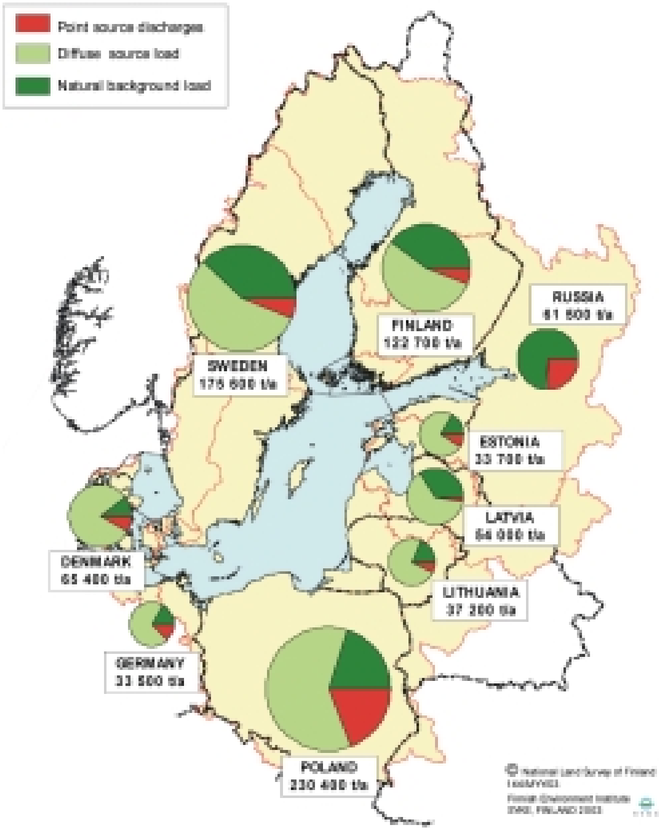
On the territory of riparian protective strips planting or preservation of trees, bushes or grass is recommended.

B.3. Management of water protection zones use

1. Maintenance of water protection zones, riparian protective strips and water protection signs (marks) in proper condition is assigned to water users.
2. Establishment of water protection zones does not entail the withdrawal of the land plots from the proprietors, land owners and land users, who are obliged to observe the established regulations on water protection and riparian zones use.
3. The state control over the observance of established size, borders and regulations on economic and other activities within the limits of water protection and riparian zones is assigned to executive authorities of the Russian Federation subjects, managerial bodies, which are responsible for water resources protection and use, and specially authorized state agencies of Natural Environment Protection.

C. Organic Farming Practices in the Leningrad Oblast as a method of reducing the eutrophication of the Baltic Sea.

C.1. Nutrient inputs into the Baltic Sea



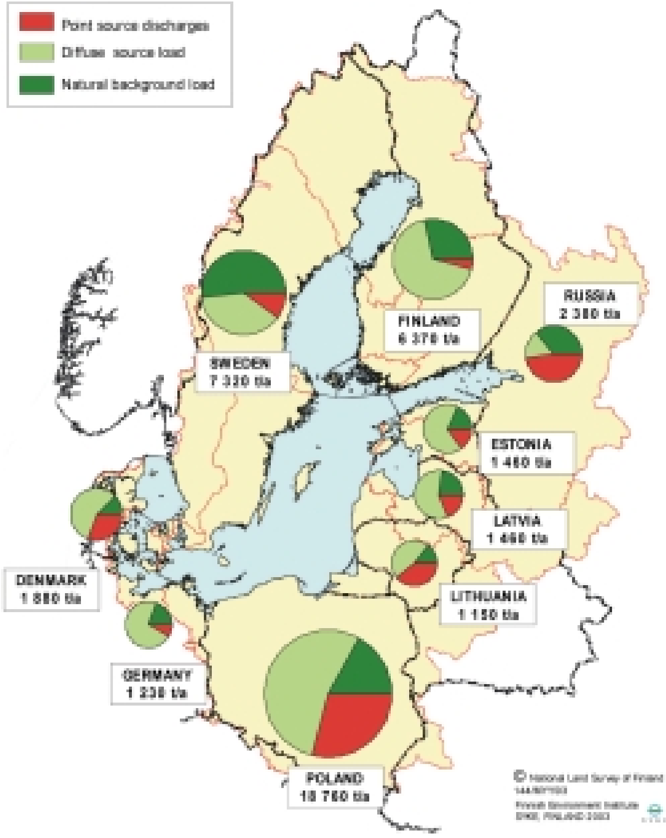
Point source discharges, diffuse source losses and natural background loads of total nitrogen (N_{total})

The Baltic marine environment protection commission (HELCOM) published in the year 2003 a summary of the riverine inputs into the Baltic Sea of all the nine member-states of HELCOM. In this comparison the total load (total nitrogen and phosphorus) of western Russia was estimated to be on the level of 61500 tons of nitrogen and 2380 tons of phosphorus per year. Western Russia means in this context the regions which cause riverine inputs into the Baltic (the oblasts of Leningrad, Pskov, Novgorod, Vologda and the Republic of Karelia). Compared to the other HELCOM member-states, the Russian load is considered to be rather moderate, which is a surprising contrast with the common opinion and the wide publicity on this item.

One of the reasons for this “moderate” load is the collapse of Russian agriculture after the perestroika. Only after the collapse of the rouble in 1998, the Russian agriculture has recovered.

The same development has been seen in the three small Baltic States, Estonia, Latvia and Lithuania, where the use of artificial fertilizers dropped nearly to zero-level during 1990-2000. However there is one significant difference between the N- and P-inputs into the Baltic of Russia compared to the other Baltic countries. While the total load of western Russia is rather low, it has to be noticed, that especially the *point source discharge* of this region is very high. The other countries show a much bigger *diffuse source discharge* (which one is nearly zero in western Russia). All the countries contribute equally in the “normal”, so called *natural background load*. The higher point source discharge of western Russia can be explained by the waste load of the city St. Petersburg itself and by the point sources of the big agrocompanies (former collective of state farms) around the Leningrad Oblast.

Nowadays, modern Russian agriculture has become very effective (especially in the Leningrad Oblast) and is more and more similar to western agrobusiness. This will without doubt result in higher point source and diffuse source discharges as has also been seen in the countries of Western Europe. Therefore the experiences



Point source discharges, diffuse source losses and natural background loads of total phosphorus (P_{total})

obtained in organic agriculture could be valuable also in the Leningrad Oblast, not only as a way of reducing local nutrient discharge but also as a response to the growing market of ecological food. The modern consumer in Russia is as much interested in food quality these days as any consumer in western countries. After the disaster of Tshernobyl the concern about food quality in Russia is even higher than elsewhere and is one of the reasons why small-scale gardening is so popular.

C.2 Present situation of organic agriculture in Russia

Organic agriculture is still not very developed in the Russian Federation, although German efforts have been done to introduce organic agriculture to Russia.

According to the information of the international federation of organic agriculture movements (IFOAM) in March 2005, there are two registered organizations in Russia: “EkoNiva” (www.ekoniva.com) and “Bisolbi-Inter” (www.bisolbi.com). They both are more involved in marketing of equipment and preparations than in the development of national norms and standards for organic agriculture. This conclusion can be made from their internet pages. Unfortunately Russia has not yet any legislation on organic agriculture, like in the EU or USA. In principle, anybody can say that he/she is producing ecological food without real control or sanctions from false statement. EkoNiva, however, tries to develop a market for organically produced food and makes on-site inspections, certifying that their farmers are producing organically grown crops. To ensure that Russian-grown products can be traded internationally, EkoNiva follows the guidelines of IFOAM. One example of this is the organic export mill Plotskoye (Kaluga Oblast), which started in 1998 and processes organic buckwheat. This buckwheat is produced organically in the Kursk region. Also organic fibre (flax) is exported from Russia to the west; mostly to Germany.

On individual level, organic agriculture is well known and, in fact, Russia is far ahead on home gardening compared to the western countries. Most of the small domestic gardens are taken care of very carefully and the skills of composting and crop rotation are widely used. The use of different non-chemical methods for crop protection is based on old and sound experiences and much of this knowledge could be used in the west. Unfortunately, the use of chemicals is changing more and more these ecological practises, due to intensive marketing and lots of commercials.

Anyhow, organic products have come to Russia. The Russian company Grunwald opened recently its first bio-supermarket in Moscow and the company believes that the potential demand for natural products is great in Russia. They will first sell natural

products, furniture, groceries and cosmetics from European manufacturers, but they believe that later on national production will replace foreign products and goods.

Russian agricultural scientists are interested in organic agriculture. The German university of Hohenheim has held lectures on organic agriculture at the Timirjasev Agricultural academy. The St. Petersburg State Agrarian University and Ruralia-institute (Mikkeli, Finland) tried to organise about ten years ago a broad and long-term exchange of Finnish know-how on organic farm practices to the Leningrad Oblast. The time was probably not yet ripe for this cooperation, although the dean of Pushkin told that his students were very interested in this subject. Unfortunately the European Union did not fund this starting cooperation. The All-Russian Agricultural College in Sergijev Posad (Moscow Oblast) has held many conferences on ecological (organic) agriculture and Sergijev Posad can be considered as one of the centres of Russian organic agriculture.

Russia needs now legislation on organic agriculture. Only after the creation of basic standards and norms and the organising of a sound control-practice, organic agriculture can start to grow in Russia.

C.3. What could be done in the Leningrad Oblast?

Considering the huge amount of consumers in St. Petersburg and the growing nutrient output surplus of modern agriculture practices, one could believe that there is potential for organic agriculture in the Leningrad Oblast. At least the positive experiences of organic farming on some of the big state-owned agro companies in the region should be used for environmental protection and for dropping production costs. According to the international IFOAM standards many of these big agrocompanies have a too intensive and too “industrial” animal production (animal density per hectare etc), but that still does not prohibit the improvement of their farm practices towards a more ecological direction.

To obtain fast and concrete results one could give four main items to proceed with in the development of organic agriculture in the Leningrad-region.

C.3.1. Introduction of a study program on organic agriculture at St. Petersburg State Agrarian University and some of the agricultural colleges in the oblast:

This seems to be one of the most important ways to get young agricultural professionals more familiar with the ecological production of meat, milk and other food. It is possible and desirable to use Russian experts as teachers, but especially at the beginning foreign specialists and researchers are needed. One of the most important tools will be writing a good handbook on organic agriculture in the Russian language. The easiest and fastest solution seems to translate one of the Finnish or Swedish handbooks into Russian, because these Nordic countries have the same climate and most of the same plant protection problems as in Leningrad Oblast. The start of a new cooperation between SLU/Uppsala, Department of Agroecology/University Helsinki and Ruralia-institute (also University of Helsinki), Mikkeli, could be possibly quite fruitful.

C.3.2. Creation of a big organic model farm on one of the bankrupt state owned farms in the oblast:

The sooner an organic model farm will be created in the Leningrad Oblast, the better. This farm is needed to show both students and directors of agro companies the practices used in organic agriculture. It is probably the easiest way to start an organic dairy farm, because in other Nordic countries this farm type has been the most successful case of organic farming. Success has not only been economical but also ecological. For example the study case of the Öjebyn farm in North-Sweden showed significant success and a drastic decrease of the use of mineral fertilizers (see: http://www.njv.slu.se/sections/animal/organic.cfm). It can even be possible to restart the production of a bankrupt state farm without the use of imported capital or fertilizers, but anyway a model farm is needed both as case study and as an educational farm. Especially the appropriate use of (liquid) manure, combined with a sound crop rotation and nitrogen fixation are the most important factors in a successful model farm. The riverine discharge and gross output of nutrients is very relevant and this model farm should become also a case study for Russian environmental research.

C.3.3. Use of some of the most successful organic farm practices in some of the big agrocompanies:

Both in Sweden and Finland the best economical and ecological results have been obtained on dairy farms, where the fields are cultivated organically but the cattle is kept in a conventional way (“normal” feeding with industrial fodder, cowshed-conditions, etc). This means the introduction of red and white clover in lays, full exploitation of nitrogen fixation, effective and ecological usage of manure and also the use on *nutrient balance calculations*. In Finland the late academic A.I.Virtanen introduced an effective and economical use of red clover combined with a strict crop rotation and a wise use of manure. His methods are still used in organic farms and also the Swedish experimental farm Öjebyn used the same method. In Russia, academic K.A.Timirjasev draws exactly the same conclusions as Virtanen: that it is possible and desirable to grow protein-rich crops cheap and effectively with the intelligent use of the nitrogen fixation of red clover. The introduction of these methods should be started at the beginning on small scale (10-100 hectares) in order to convince the experts of the big farms. It should be stressed that the use of liquid manure should happen at the establishment of a new lay and later on only when the amount of red clover has strongly decreased in the lay.

C.3.4. Large-scale production of compost for gardening of consumers, with the use of chicken manure, peat and Scandinavian know-how:

Around St. Petersburg there are located several big agrocompanies with a huge production of eggs and broiler meat. These effective and modern farms are however struggling with an enormous amount of chicken manure (up to 300 tons/day/company). The high popularity of horticulture among the population and the rising interest in natural products from own garden offer very good possibilities to circulate this manure more effectively and to create good agrobusiness, like it has been seen in Finland (Companies Biolan, Kekkilä, etc).

The dung problem of these big farms could and should be solved in the same way as it has been done in Finland: to produce black, nutrient-rich, humus compost in smaller and bigger packages for the amateur gardeners. In fact, the situation is ideal: near a population of 5 million and thousands of gardening plots, the production of compost can be started. One of the best and most concrete results of this CGAP-project is the starting of a compost production line in one of these chicken farms. This goal can be achieved without any bigger efforts. Only the right contacts need to be made (Russian capital, suitable poultry company and the know-how and shares of Finnish or Swedish companies).

C.4. Short conclusion

The growing effectiveness of the modern agriculture around St. Petersburg justifies the worry on increasing discharge of nutrients. Therefore it is most important to introduce the education of organic agricultural methods both in the university as in agricultural colleges. The main tools for a more ecological agriculture in the Leningrad Oblast are:

- wise use of manure (only spring and summer application)
- good crop rotation, combined with effective use of nitrogen fixation (clover lays)
- appropriate animal density (less then 1,5 animal unit/hectare)
- use of nutrient balance calculation (BitFarm computer program)
- creation of at least one organic model farm in the oblast
- writing or translating a handbook for organic agriculture (*urgent!*)
- legislation of basic standards for organic agriculture
- effective control of organic production
- wider use of ecological practices also on big conventional agrocompanies
- transforming chicken manure into a good selling product: garden-compost